UNIVERSITY OF ILLINOIS

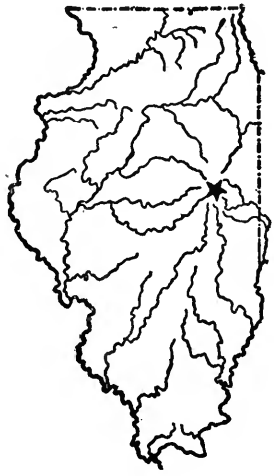
Agricultural Experiment Station

BULLETIN No. 231

THE HORSE AND THE TRACTOR

AN ECONOMIC STUDY OF THEIR USE ON FARMS IN CENTRAL ILLINOIS

By W. F. HANDSCHIN, J. B. ANDREWS, and E. RAUCHENSTEIN



URBANA, ILLINOIS, FEBRUARY, 1921

CONTENTS OF BULLETIN NO. 231

THE HORSE AND THE TRACTOR

AN ECONOMIC STUDY OF THEIR USE ON FARMS IN CENTRAL ILLINOIS

By W. F. Handschin, Chief in Farm Organization and Management, and J. B. Andrews and E. Rauchenstein, Associates

INTRODUCTION

The working out of scientific methods in management has been one of the most important advances made in American industry during the past twenty years. Scientific management has enabled the business man to make great economies in time, energy, and material used, and has resulted in greatly increasing the output per worker in nearly every important American industry.

The same is true in agriculture to a very considerable extent, altho this fact is not generally appreciated, even by farmers themselves. The substitution of farm machinery and horse power for hand labor, alone, increased the output of the farm worker in the United States from two and one-half to twenty times during the period from 1830 to 1895, most of this change taking place between 1865 and 1895. Important improvements in the use of machinery and horse power have been made since 1900.

The remarkable record in food production made by American farmers during the war ranks second to the achievement of no other industry. This record was made possible mainly by the increased use of machinery and horse power and the improvement in methods of management. Naturally, as in all other industries, the farmer and his family worked harder than ever before in order to overcome the shortage of man labor. But even in normal times the output per worker on the American farm greatly exceeds that of any other nation. This fact is due to the abundant supply of good land, the substitution of machinery and horse power for hand labor, and to the methods of management employed.

In spite of these facts, we are apt to speak as tho all the advances in improving methods of production and in working out scientific methods of management had been made in the city industries. This somewhat earlier development of scientific management in industry as compared with the development in agriculture has been due largely to the fact that manufacturing, merchandising, and transportation have been carried on in relatively larger units than has the business of farming. These industries have thus been enabled to install cost-

accounting systems and to take up the problems of scientific management in their individual businesses. The study of these problems in a large number of individual plants has furnished the basis for the development of the whole field of scientific management in industry.

Because farming has been carried on in small units as compared with other industry, it has not been possible for the individual farmer to make detailed studies of his business with a view to improving production and introducing scientific methods in management. However, the investigation of these problems has been undertaken during recent years by a number of public institutions somewhat specially equipped for carrying on such studies.

In 1902 the University of Minnesota, in cooperation with the Bureau of Statistics of the United States Department of Agriculture, began a series of studies in the cost of producing farm crops in Minnesota. These studies have been carried on continuously during the past eighteen years. In the meantime their scope has been enlarged to include the study of costs for all farm products and the entire problem of the scientific organization and operation of the farm as a business unit. These studies have been of great value in furnishing the beginnings of a scientific basis for the study of the individual farm business. Other institutions have taken up work along these lines during the past ten years. Most prominent, perhaps, have been the Office of Farm Management of the United States Department of Agriculture, the University of Wisconsin, Cornell University, and the University of Illinois. Several others have made a substantial beginning.

From these studies alone, a considerable amount of valuable information has been assembled regarding the scientific organization and operation of farms in various sections of the country. The possibilities which this information affords in improving the methods of management in farming become apparent when we note the high degree of skill which has been developed by a very considerable number of individual farmers thruout the country in the scientific management of their farms, and this in spite of the fact that they themselves have scarcely been conscious of having worked at the problem. And yet only a fair beginning has been made in getting at the principal facts in the successful organization and operation of farms. It has been necessary not only to collect and classify the facts, but also to construct a language in which to discuss them. The literature of the subject is almost entirely undeveloped.

One of the most important needs at the present time is the analyzing and translating of the facts being gathered on the more successful farms into terms of principles and working formulae which may be applied to other farms carrying on the same types of farming under similar conditions. Naturally, as the field of scientific management

in agriculture develops, more refined methods of studying the organization and operation of farms will be worked out, and the studies will be extended to include every important type of farming.

In Illinois the study of farm organization and management has been under way since 1912. The work has been along the three following lines:

First: Detailed accounting and management investigations carried on in several sections of the state during the past seven years. These studies were undertaken by the Department of Animal Husbandry in 1912, as a part of their investigation of systems of livestock farming. In 1917, when the Department of Farm Organization and Management was organized, the work was transferred to that department, in which it is being continued.

These studies have included the keeping of detailed cost accounts for each of the farms studied. Complete production records for all the crop and animal enterprizes have been kept, as well as detailed records of man labor, horse labor, and machinery use. These records have afforded the opportunity to make detailed analysis of the work done on the farm studied from the standpoint of the amount and kind of work done, and its distribution thruout the various months.

Second: General farm accounts kept on several hundred farms in some twenty different counties in central Illinois. These accounts have been kept in connection with the extension work carried on by the Department of Farm Organization and Management during the years 1915 to 1918 inclusive. They have included a financial record of the farm business, an annual inventory, a record of farm receipts and expenses, and records of production for both crop and animal enterprizes.

Third: Survey studies carried on during the fall of 1918 in cooperation with one hundred farmers operating tractors in six central Illinois counties. These studies were undertaken to learn what results farmers were getting in the use of tractors under actual farm conditions.[1]

Problems in the use of horse labor were selected for special study and publication at this time because of the wide interest in these questions on the part of farmers, especially in the corn-belt section. This interest is based mainly on two factors: first, a more general appreciation by farmers that horse labor makes up a relatively large part of all farm operating expense, and that it, above all other items of expense, is the one which can be profitably reduced by good methods of farm organization and operation; and second, the great in-

[1] Additional tractor-survey records have been secured during 1919 and 1920. These include data from more than four hundred farms which have used tractors from one to six years. These farms are located in nineteen counties in northern, central, and southern Illinois.

crease in the number of tractor manufacturers and the use of tractors during the past few years.

The increased output of farm tractors and the large amount of advertising being done by those interested in their further introduction make it desirable to give to farmers at this time any information which may be of help to them in solving their problems in the most economical use of farm power. Owing to the fact that the farm tractor is still in its formative period, any studies as to its use and the extent of its application made at the present time must of course be considered as preliminary. The results herein reported are, it is believed, fairly representative of the experience of general farmers in the areas studied. With the advance being made in tractor manufacture and design, it is obvious that such studies should be continued each year. Naturally these studies should include a greater number of farms and should cover each of the important types of farming areas where tractors are being introduced.

Special acknowledgment is due Professor E. A. White, formerly head of the division of Farm Mechanics, and Professor J. L. Edmonds, head of the division of Horse Husbandry, for valuable assistance rendered in these studies. Special credit is also due to the group of some thirty farmers who have cooperated painstakingly in the detailed cost-accounting studies carried on during these investigations.

PART I

NATURE OF THE STUDY

AREAS STUDIED

The data on the cost and use of horse labor reported in the following pages are based mainly on cost-accounting and general-management studies carried on in Hancock county, Illinois, during the years 1913 to 1918 inclusive.

Hancock county is a typical live-stock farming section. Corn is the principal crop grown. Oats rank second in importance, with hay, principally clover and timothy, ranking third. Fall wheat and rye are grown to a considerable extent. The wheat acreage declined from 1910 to 1915, but has increased since that time. Practically all the crops grown, with the exception of wheat, rye, and some hay, are fed within the county. Some corn is occasionally shipped in. Beef cattle and hogs make up a very large proportion of all farm products sold. Dairying and the production of sheep and wool are relatively unimportant. The general type of farming carried on is fairly representative of the entire area lying between the Illinois and the Mississippi rivers. This area is by far the most important general live-stock-producing region of the state.

Most of the farms included in these studies are practically all tillable. They grow a somewhat smaller proportion of corn and a somewhat larger proportion of hay and wheat than is generally grown on farms in east-central Illinois. From the standpoint of the cropping systems used and the horse-labor requirements of crop production they may be considered fairly representative of the entire west-central section of the state.

DATA AVAILABLE

While the greater part of the data presented was obtained on some twelve different farms included in the detailed-accounting and general-management studies carried on in Hancock county, similar data were available for farms in several other sections of the state. Detailed accounts were kept on six to ten general farms in Franklin county during the period from 1913 to 1918 inclusive. Individual farms were studied in three additional areas of the state: one general farm in Randolph county during the five years from 1914 to 1918, one grain and live-stock farm in Champaign county during the five years 1914 to 1918, and one large cattle-feeding farm in Henry county during the three years 1915 to 1917. In the aggregate, detailed accounts, including the determination of costs, were available for one hundred and twelve farm years, i.e., an average of 22.4 farms for each of the five years 1913 to 1917. In addition to this, some

four hundred simple farm accounts were available for study. These included data as to the area in various crops, the number of work horses carried, the amount of live stock produced, the yields, and general financial results of the farm business. These simple farm accounts were for the years 1915 to 1918 inclusive and represented twenty different counties in the central section of the state.

The records on the use of farm tractors were obtained during the fall of 1918 by means of personal interviews with one hundred farmers each of whom had used his tractor one or more years. The farms represented in this study are located in six central Illinois counties.

SEASONAL VARIATIONS

During the period covered by these studies, wide seasonal variations occurred in the different areas. These included variations in rainfall, frost dates, and other factors having a vital influence on crop production and the use of horse labor. For example, while the average annual rainfall for Hancock county during the period from 1913 to 1916 was 30.82 inches, the annual rainfall varied from 25.94 inches in 1914 to 38.93 inches in 1915. For the months of May, June, and July, during which the peak load of horse labor usually comes, the following extreme variations in rainfall occurred between the different years: In May, 1914, the rainfall was 1.73 inches; in May, 1915, 5.79 inches. In June, 1914, the rainfall was 3.34 inches; in June, 1915, 9.99 inches. In July, 1914, the rainfall was 2.09 inches; in July, 1915, 6.34 inches. Such variations in rainfall during the cropping season bring about great changes in the use of horse labor during different years. Because of this variation alone it is important to have records covering several consecutive years before an attempt is made to draw conclusions regarding the use of horse labor and the horse-labor requirement of different crops.

TYPE OF HORSES USED

The size and type of horses used in Hancock county and the general methods of feeding and management followed are considered fairly typical of the entire central and northern portions of the state. Most of the horses showed a predominance of Percheron blood. With but few exceptions they ranged in age from three to fifteen years, and varied in weight from 1,300 to 1,500 pounds. They were kept primarily for draft purposes. A few colts were produced on practically all the farms studied, but no mares were used exclusively for breeding purposes.

IMPORTANCE OF STUDYING HORSE-LABOR COSTS

Profits in farming, as in any other business, are determined by the operating expense quite as much as by the gross income, and as

in most other enterprizes, the operating expense is the only item which can be controlled to any great extent. In attempting to reduce the expense of production in ordinary types of farming, horse labor offers a larger opportunity than any other item, since it makes up a relatively large proportion of all operating expense and can be more favorably influenced by good farm organization and operation than can any other item.

In the types of farming studied, man and horse labor together make up from 80 to 90 percent of the total operating expense, horse labor alone making up 30 to 40 percent. While man labor represents a somewhat larger proportion than does horse labor, it does not offer so large an opportunity for better utilization since in most cases it is being used to much greater advantage, and moreover it can be laid off, thereby stopping expense, when there is no work to be done.

Other items of farm operating expense, such as fertilizers, twine, seed, spray materials, threshing, silo filling, baling hay, telephone, and other miscellaneous cash costs, make up a relatively small proportion of the total operating expense. These are necessities which must be purchased at fixed prices and they therefore offer little opportunity for economies in operation.

While the operating expense in the types of farming studied makes up only from 45 to 65 percent of the total farm expense, the other items of expense offer little opportunity for making economies. Most of these are made up by such fixed, or overhead, charges as interest on the investment in land, buildings, and equipment, and the depreciation on buildings, machinery, and tools. Few of these items can be materially reduced. They are therefore relatively unimportant in the problem of reducing the total farm expense.

PART II

THE COST OF HORSE LABOR

THE VARIOUS ITEMS ENTERING INTO THE COST OF KEEPING HORSES

The costs which enter into the keeping of farm horses are feed, labor or care, shelter, interest on investment, harness expense, and miscellaneous cash expense, such as veterinary service and shoeing. The relative importance of each of these items as found on the farms of Hancock county under investigation during the years 1913 to 1918 is shown in Table 1 and Fig. 1.

As an average of these six years, feed represented 72 percent of the total cost of keeping work horses and may therefore be considered the most important item. The percentage of the total cost made up by feed increased from 67.5 percent in 1913 to 78.8 percent in 1917, which may be explained by the fact that between these years the cost of the feed used increased more rapidly than did the cost of other items. The percentage decreased slightly in 1918, owing to the fact that the other items of cost increased relatively more than did feed.

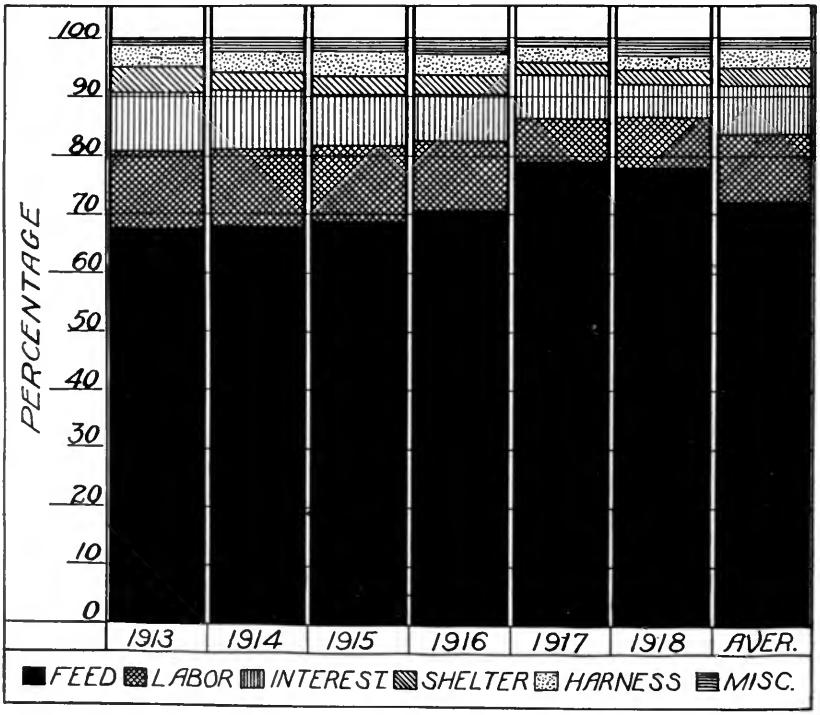


FIG. 1.—PERCENTAGE WHICH EACH ITEM OF EXPENSE CONSTITUTED OF THE TOTAL COST OF HORSE LABOR, 1913-1918

TABLE 1.—PERCENTAGE WHICH EACH ITEM OF EXPENSE CONSTITUTES OF THE TOTAL COST OF HORSE LABOR, 1913-1918

	Feed	Labor	Interest	Shelter	Harness	Misc.
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1913.....	67.5	13.5	9.8	4.3	3.7	1.2
1914.....	68.0	12.3	10.0	3.3	3.9	2.5
1915.....	68.7	12.3	8.8	3.5	4.4	2.3
1916.....	70.7	11.8	8.0	3.2	3.5	2.8
1917.....	78.8	9.0	6.0	2.2	2.8	1.2
1918.....	78.0	8.7	5.6	2.1	2.4	3.2
Average...	71.95	11.28	8.03	3.10	3.44	2.2

The cost of shelter did not increase during this period because the chief items of building expense, that is, interest and depreciation, were based upon the value of buildings as inventoried before the rapid rise in prices.

The interest on investment in horses shows no increase, since the value of horses actually decreased during the five years and there was no change in the interest rate used.

Harness expense was also determined on the basis of the pre-war values because most of the harness was on hand before prices began to rise. Some harness was purchased at increased prices but not enough to affect materially the total expense.

Miscellaneous expenses were small. With these expenses, variations do not depend so much upon price variations as upon the amount of such miscellaneous items used.

TOTAL COST OF KEEPING HORSES

The total cost of keeping farm work horses is determined largely by their care and management, and by the amount, kind, and price of feed used. The average annual costs of keeping one horse during the years 1913 to 1918 on the farms studied are given in Table 2 and Fig. 2.

TABLE 2.—AVERAGE ANNUAL COST OF KEEPING ONE HORSE, 1913-1918

Year	Feed	Labor	Interest	Shelter	Harness	Misc.	Total
1913.....	$59.27	$11.88	$8.58	$3.73	$3.24	$1.09	$87.79
1914.....	59.19	10.69	8.72	2.91	3.36	2.22	87.09
1915.....	65.90	11.85	8.43	3.39	4.27	2.18	96.02
1916.....	63.73	10.66	7.24	2.87	3.16	2.50	90.16
1917.....	103.18	11.80	7.79	2.91	3.72	1.54	130.94
1918.....	122.14	13.66	8.78	3.29	3.75	4.96	156.58

Depreciation in work horses[1] does not appear as an item of expense because of the fact that the horse account, as kept, is practi-

[1]All horses three years old or over are counted as work horses in these studies.

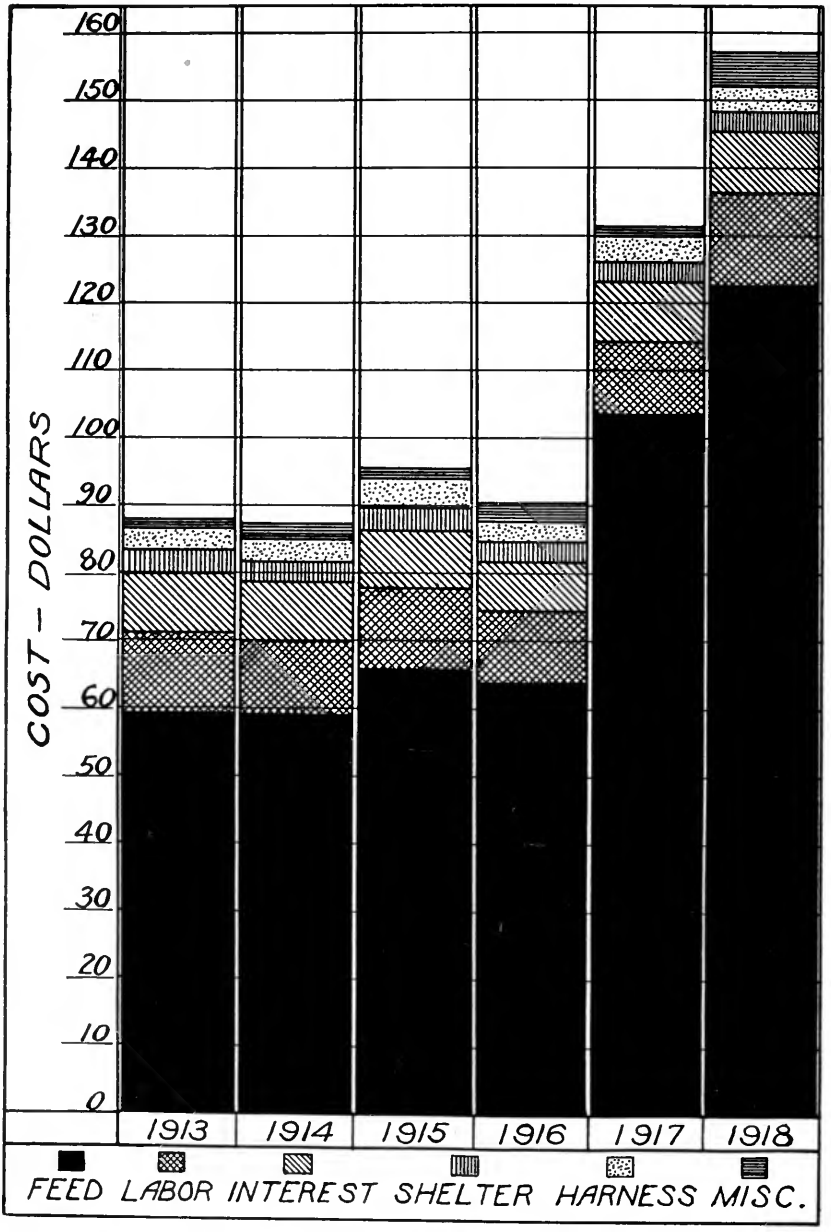


FIG. 2.—AVERAGE ANNUAL COST OF KEEPING ONE HORSE, SHOWN BY THE VARIOUS ITEMS OF EXPENSE, 1913-1918

cally an account of all horses, including work horses and colts; and what would be an item of depreciation is covered by the charge made for feed used in growing the colts and young horses. The average depreciation on all work horses was estimated at about 10 percent per year.

Since feed is the largest item of expense, and since the other items are fairly constant, the variations in the average total cost as shown by Table 2 are due almost entirely to changes in the prices of feed and the amounts used. The slightly lower cost in 1916 over 1915 was due to a decrease in the amount of hay consumed and also to a decrease in the price of hay. The decrease in the cost of hay consumed was considerably more than the increase in the cost of grain fed, even tho the average price of corn increased 10 cents per bushel. The increases in the total cost of keeping horses during 1917 and 1918 were caused almost entirely by the increased prices of feeds. The total amount of feed consumed annually by all horses on all farms did not vary to any great extent from one year to another. In comparing different farms, however, considerable variation in the average amounts of feed consumed per horse was found during each of the six years.

MEASUREMENT OF HORSE-LABOR EFFICIENCY

In studying the use of horse labor with a view to making comparisons between different farms and between different years, some standard measures are necessary. The following four standard measures were selected as offering the most satisfactory basis for such comparisons: (1) crop acres per horse; (2) hours per horse per year; (3) hours per horse per day, and (4) cost per horse per hour.

The efficiency of horse labor on all the farms studied in Hancock county, as measured by these four standards, for each of the five years 1913 to 1917, is presented in Table 3.

The average number of crop acres worked per horse shows some variations during the five-year period from 1913 to 1917. The increase from 16.72 in 1914 to 22.44 in 1915 was due largely to the fact that two of the farms included practically doubled their acreage without making a corresponding increase in the number of horses carried. In 1916, when some additional horses were taken on by these two farms, the number of crop acres worked per horse decreased to 19.87. The increase made by all the farms in the number of crop acres worked per horse in 1917 was due to several factors. The increased price of feed and the better appreciation by the cooperating farmers of the number of horses required to handle satisfactorily a certain number of crop acres, led to a reduction in the number of horses on some farms. The increase in the acreage farmed by two of the farms included also made possible a better utilization of horse labor, and

therefore a larger number of crop acres per horse. For a fuller discussion of the influence of the size of farm on the number of crop acres farmed per horse, see page 189. On the basis of simple farm accounts kept on three hundred and sixteen farms in twenty central Illinois counties, during the years of 1916, 1917, and 1918, the average number of crop acres worked per horse was 18.56.

The number of hours of work per horse per year averaged 928.2 for the five-year period. The average for each year did not vary greatly from this figure. The somewhat lower number of hours worked per horse during 1914 (818.7) was due largely to the dry season. In normal years it is necessary in growing cultivated crops to work the ground as soon as practicable after each rain in order to break the crust and kill weeds, but in 1914 such extra workings were unnecessary, as there was practically no rain during the growing season. Also the smaller crop yields required much less labor in harvesting. In 1915 the rainfall during the growing season was considerably above the normal. This, however, was not the cause for the increase in the number of hours of horse labor for that year. It did make necessary more than the average amount of work for some of the operations, such as preparing the ground for the crops and cutting small grain, but on the other hand it prevented some of the work from being done. Some crops were not put in, others were not harvested, and most of the corn was given much less than the usual amount of cultivation. The reason for the increase was that two of the farms

TABLE 3.—EFFICIENCY OF HORSE LABOR AS MEASURED BY THE FOUR STANDARDS, 1913-1917

Year	Average crop acres per horse[1]	Average hours per horse per year[2]	Average hours per horse per day[3]	Average cost per hour[4]
1913.....	17.57	943.5	3.02	$ .0971
1914.....	16.72	818.7	2.62	.1254
1915.....	22.44	1046.7	3.35	.1034
1916.....	19.87	923.1	2.95	.1027
1917.....	22.48	926.0	2.96	.1481
Average.....	19.95	928.2	2.98	

[1]*The average number of crop acres per horse* represents the number of acres in cultivated crops for each work horse kept. While different crops require varying amounts of horse labor, this measure is considered a fair basis for comparison between different farms carrying on the same general type of farming.

[2]*The average number of hours of horse labor per horse per year* is determined by dividing the total number of hours worked by all horses during the year by the number of work horses carried. This includes the Sunday labor performed, such as caring for live stock and other necessary work.

[3]*The average number of hours worked per horse per day* is determined by dividing the average number of hours worked per horse per year by 312.

[4]*The cost per hour of horse labor* is determined by dividing the total net cost of keeping all work horses carried for a year by the total hours of work done by the horses during that year.

studied increased their area by 160 acres each, without a corresponding increase in the number of work horses. During 1916 and 1917 the number of work horses on these two farms was increased somewhat and the hours per horse returned to almost normal.

The hours of horse labor per horse per day averaged approximately three (2.98), indicating that the horses on these farms did not approach their maximum utilization.

The average cost of horse labor per hour for the years 1913 to 1916 on the farms studied remained fairly constant, the minimum for this period being $ .0971 in 1913 and the maximum $ .1254 in 1914. In 1917 the average cost per hour increased to $ .1481. This increase was due largely to the rise in the price of feeds.

VARIATIONS IN HORSE-LABOR EFFICIENCY

The variations in the number of crop acres and the number of hours of labor secured per horse, as well as the wide variations in the cost of horse labor per hour on the different farms studied, which are shown in Table 4, emphasize the importance of making a most careful study of these items. The farms included in this group were all carrying on the same general type of farming on the same or similar soil types. They were all located within a few miles of each other and therefore had the same seasonal conditions as to rainfall and other factors affecting the use of horse labor.

TABLE 4.—EXTREME VARIATIONS IN HORSE-LABOR EFFICIENCY ON THE FARMS STUDIED IN HANCOCK COUNTY, 1913-1917

Year	Crop acres per horse		Hours per horse per year		Hours per horse per day		Cost per hour	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1913.....	12.92	25.13	543	1582	1.74	5.09	$ .0524	$ .1520
1914.....	10.74	21.73	436	1353	1.42	4.33	.0576	.2103
1915.....	16.38	30.94	781	1400	2.50	4.49	.0544	.1685
1916.....	14.34	29.03	657	1210	2.10	3.88	.0733	.1371
1917.....	17.78	29.40	573	1321	1.83	3.98	.1128	.2579

The variations shown in Table 4 are of two kinds: variations within the same farm or group of farms from one year to another; and the variations between different farms during the same year.

The variations in the utilization of horse labor which occurred from one year to another were due largely to seasonal variations, principally differences in rainfall during the cropping season. Some of these variations, however, were due to changes in farm organization and operation which were being put into effect by different farms. The variations in the cost per hour of horse labor from one year to another were due to the influence of either one or both of two factors: first,

to a general increase in the cost of feed and other items as shown in Fig. 2; and second, to changes in the organization and operation of the individual farm. For example, the material increase in minimum cost per hour which occurred during both 1916 and 1917, as shown in Table 4, was almost entirely due to the constantly advancing price of feed (the minimum cost per hour was secured by the same farm during each of the five years); while it was owing mainly to a reduction in the number of horses carried that the maximum cost per hour (secured by an individual farm in 1913, 1915, 1916, and 1917) was materially reduced during 1916 as compared with 1913 and 1915. Owing largely to the increase in the cost of feed, the rate per hour for this farm was again greatly increased in 1917. Other management factors also entered into this increase in cost from 1916 to 1917.

The variations which occurred between different farms during the same years were due largely to differences in the organization and operation. Thus, the farm which had the lowest cost per hour in 1913 consistently remained the lowest in this item thruout the entire five-year period. During each of these years it produced its horse labor at a cost ranging from approximately one-half to one-third the cost on the farm having the highest rate for the same year.

The farms tended somewhat consistently to rank in the same order when compared with reference to their efficiency in any one of the four factors during a given year. For example, the farm working the largest number of crop acres per horse was, in general, the farm securing the largest number of hours of horse labor per year and per day, and also the lowest cost of horse labor per hour. Conversely, the farm working the lowest number of crop acres per horse was, in general, the farm securing the lowest number of hours of horse labor per year and per day, and also the highest cost of horse labor per hour.

It is of course appreciated that the cost-accounting studies upon which this work is based do not afford an exact measure of the value of the horse hour on one farm as compared with that on another. However, the figures here reported are considered to be fairly comparable. As has already been pointed out, the farms included were all carrying on the same general type of farming and the horses used were, in general, of the same size and type. There is no evidence that the horse hour costing $ .152 represented any more or better work done than that costing $ .0524. There were inevitably some variations in the quality of the horse hour on the various farms studied, but such variations were unimportant as compared with the differences in cost per hour of horse labor. For the purpose of this analysis we may therefore assume that the cost per hour affords a satisfactory standard of measurement in comparing the efficiency of horse labor on the different farms.

INFLUENCE OF COST PER HOUR ON THE COST PER ACRE

When these differences in the cost of horse labor are expressed in terms of cost per acre, the importance of horse labor as an item of cost in producing farm crops may be more fully appreciated.

In Table 4 it will be noted that the cost per hour varies in general more widely than any of the other standard measures of horse labor. As previously stated, the cost of horse labor per hour depends upon the combined influence of two factors, i.e., the total cost of keeping a horse for a year, or any other given period, and the number of hours of work done during this period. Since of the farms studied those having the lowest total costs for keeping horses also secured the largest number of hours of work per year, and those securing the lowest number of hours of work per year were nearly always among the group having the highest total cost of keeping their horses, the variations in the cost per hour of horse labor were extreme.

TABLE 5.—EXTREME VARIATIONS IN ACRE COST OF HORSE LABOR WHICH WOULD RESULT FROM THE MINIMUM AND MAXIMUM HOUR COSTS OF HORSE LABOR

Crop	Hours horse labor required per acre	Cost at maximum rate of $ .152	Cost at minimum rate of $ .0524	Difference in cost per acre	Difference per thirty acres
Corn.....	46	$6.99	$2.41	$4.58	$137.40
Corn.....	46	6.99	2.41	4.58	137.40
Oats.....	18	2.74	.94	1.80	54.00
Wheat.....	38	5.78	1.99	3.79	113.70
Clover.....	12	1.82	.63	1.19	35.70
Total difference in cost for 5 years' rotation of 150 acres.....					$478.20
Total difference in cost per acre					$3.19

Table 5 shows the differences there would be in the cost of horse labor per acre when figured on the minimum and on the maximum costs per hour obtained in growing the standard corn-belt crops (corn, oats, wheat, and clover) during 1913. Similar variations in cost occurred during each of the other years. This table also shows the total differences there would be in the cost of horse labor per acre in growing 150 acres of these crops in the following rotation: corn, 60 acres; oats, 30 acres; wheat, 30 acres; and clover, 30 acres; i.e., a rotation of corn, corn, oats, wheat, and clover.

Since corn requires on the average 46 hours of horse labor per acre, the difference in the cost of producing an acre of corn, due to this item alone, would be $4.58. For oats, which require 18 hours of horse labor, the difference in cost would be $1.80. For fall wheat, which requires 38 hours, the difference would be $3.79. For clover, which requires 12 hours, the difference would be $1.19. As shown in the right-hand column in Table 5, the difference between

the minimum and maximum costs of horse labor in growing a rotation of corn, 60 acres; oats, 30 acres; wheat, 30 acres; and clover, 30 acres, would be $478.20 for the entire rotation of 150 acres, or $3.19 per acre, as an average for the various crops.

Assuming a difference of $3 per acre between the minimum and maximum costs of producing the crops grown in a farm rotation and translating this difference into terms of interest earned, we should have 1½ percent interest on $200 land, or 1 percent interest on $300 land. Translating this difference of $3 per acre into terms of capitalized income, it will be seen that with interest at 6 percent it represents a difference of $50 per acre in the value of the land, or with interest at 5 percent, a difference of $60 per acre. That is, on the basis of the differences in the cost of horse labor actually found, some farmers can pay 1½ percent more interest on $200 land, or 1 percent more interest on $300 land, than can others. Figuring interest at 6 percent, one farmer can pay $50 more per acre for a given piece of land, or with interest at 5 percent he can pay $60 more per acre, taking into consideration the differences in the cost of horse labor alone. From these figures it is evident, therefore, that the variations which actually occur in the cost of horse labor are responsible for considerable variation in the cost of producing farm crops, and must, therefore, materially affect the total profits of the farm business.

PART III

REDUCING THE COST OF HORSE LABOR

The differences in the cost of horse labor which occurred during each of the five years 1913 to 1917, as shown in Table 4, emphasize the importance of studying this item of expense with a view to reducing it to the lowest possible point consistent with good practice and the largest return for the farm business as a whole.

In attempting to reduce the cost per unit of horse labor, two factors are to be considered as of primary importance; namely, the reduction of the net cost of carrying the horses, and the securing of the largest amount of productive work per year, or other given period, per horse. The reduction of the net cost of carrying the horses can be effected mainly thru economical feeding, care, and general management, thru raising good colts for sale or to replace other horses, and thru reducing depreciation by disposing of mature horses before they begin to depreciate in selling value. In attempting to secure the largest amount of productive work per horse per year, several factors are of importance. Among the foremost are the scientific organization and operation of the farm with a view to distributing the horse labor as evenly as possible thruout the year, the more general production and use of the most efficient size and type of horse, and the care and handling of farm horses in such a way as to keep them in the best possible working condition thruout the year.

REDUCING THE NET CARRYING COST

Thru Economical Feeding, Care, and General Management.—Since feed makes up 72 percent of the total cost of keeping horses, as shown in Table 1 and Fig. 1, it presents the largest opportunity for reducing the cost of carrying farm work horses. Substantial economies in this item were effected by some of the farms included in these studies.

TABLE 6.—VARIATIONS IN THE AVERAGE COST OF FEED CONSUMED PER HORSE ON DIFFERENT FARMS, 1913-1918

Year	Minimum cost per horse	Maximum cost per horse
1913	$44.42	$79.78
1914	44.62	69.67
1915	52.53	83.87
1916	50.65	80.40
1917	56.97	131.58
1918	104.75	164.10

The figures presented in Table 6 show that it cost some farmers from one and one-half to more than two times as much to feed their horses as it did others during the same year. Some of these differ-

ences were due to differences in the size and age of the horses, the larger horses naturally requiring more feed than the smaller ones, and the young, growing horses requiring more than the mature ones. A part of the differences in feed required were also due to differences in the amount of work done by the horses. When all these factors are taken into consideration, however, there still remain differences due to the more economical method of feeding used on some farms as compared with that on others. This factor of economical feeding represents by far the most important factor in reducing the cost of carrying horses under general farming conditions.

Labor made up a relatively small proportion of the total cost of keeping horses on the farms studied. The amount of time spent in caring for horses depends not only upon the amount of attention given the animals, such as grooming, harnessing, and general care, but also upon the location and arrangement of barns, feed storage, water supply, and pastures. Horses kept in good pastures conveniently located of course require less feed and care than those kept in the stable most of the time. The best practical experience has shown that any economies in the time spent in caring for farm horses should be effected thru providing more convenient arrangements for feeding and watering rather than thru putting less time on grooming and general inspection and care. In fact, the majority of farmers might profitably spend a little more time in looking after the health and general condition of their work stock.

The shelter cost in keeping work horses is relatively unimportant. It cannot be decreased to any great extent except by providing the most inexpensive barns consistent with satisfactory housing, convenience in operation, and minimum net cost over a period of years.

By Raising Good Colts.—While the raising of colts was at most a secondary source of income on the farms studied, it was to some extent a factor in reducing the total cost of carrying the work stock. On none of the farms were brood mares kept primarily for raising colts. In fact, all mares bred did full-time service in the harness during the busy seasons.

Even tho the direct profits to be made in raising colts may not be large, the most successful corn-belt farmers find it profitable to produce at least enough colts to replace the older horses worn out or sold to avoid depreciation. Corn-belt farmers can produce colts at the lowest possible cost, since the colts can be grown to a considerable extent on legume roughage and can be raised very largely on the idle time of the mares and the least productive time of the men. In growing his own supply of horses, the farmer makes whatever profit there is in production, saves the cost of transfer from the grower to the user, and eliminates to a large extent the risks from disease in making such transfers. It is evident that if the raising of colts is

to be made most profitable, they must be of the size and quality which command the best market price when sold.

By Reducing Depreciation Charges.—The total cost of carrying farm work horses may also be reduced to some extent by avoiding the depreciation charge in so far as possible. Ordinarily farm horses are started to work at three years of age; they are in their prime at five to six years, and do not begin to depreciate in selling value until they are eight or nine years of age. This gives the farmer an opportunity to work his horses four or five years and still sell them for their maximum market value, provided they have not been depreciated thru blemishes or unsoundness.

Since approximately 90 percent of all work horses are on farms, the major portion of the depreciation must be absorbed by the farms. On the basis of the best information available, city horses wear out in from four to five years on the average, while farm horses last from eight to ten years. It is evident, therefore, that approximately 20 percent of the horse consumption of the country takes place in cities. Inasmuch as other factors than age contribute most to the wearing out of the horse on the city street, it will be advisable for the farmer to sell off his surplus horses which the city requires before they begin to depreciate on account of age. In this way from 15 to 20 percent of the depreciation charge for all farm horses may be transferred to the city. In the corn-belt section, which produces a large proportion of the surplus horses of the country, it is possible to transfer from 25 to 50 percent of this depreciation to the city or to the farming sections which buy horses rather than raise them.

SECURING A LARGE AMOUNT OF WORK PER HORSE

Thru Farms of Adequate Size.—One of the important considerations in securing the most effective utilization of horse labor is the size of farm. The figures shown in Table 7, presenting data from

TABLE 7.—SHOWING THE INFLUENCE OF THE SIZE OF FARM ON THE NUMBER OF CROP ACRES WORKED PER HORSE, 1916-1918

Size of farm	Number of farms	Aver. size of farm	Aver. number crop acres	Crop acres per horse
Under 160 acres	81	111.2	87.4	14.69
160-199 acres	107	167.0	137.6	17.59
200-239 acres	47	209.7	172.1	18.86
Over 240 acres	81	299.6	240.0	21.38
Average crop acres per horse on 316 farms				18.56

316 farms located in some twenty counties in central Illinois, show the influence of the size of farm on the number of crop acres worked per horse. On the basis of these figures, the number of crop acres

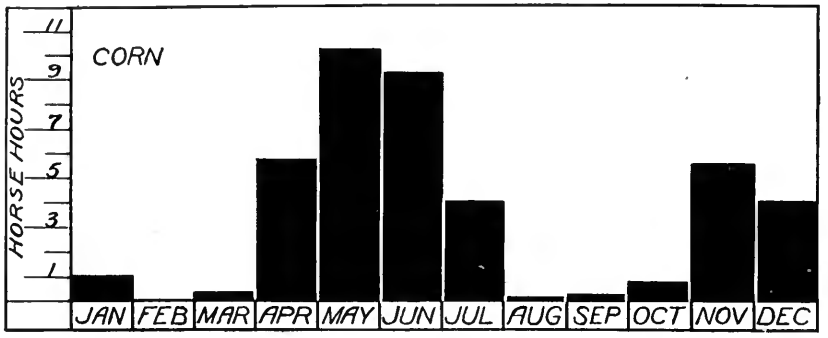


FIG. 3.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF CORN WHEN NO PLOWING OR MANURE HAULING WAS DONE IN THE FALL. TOTAL HORSE HOURS, 40.9

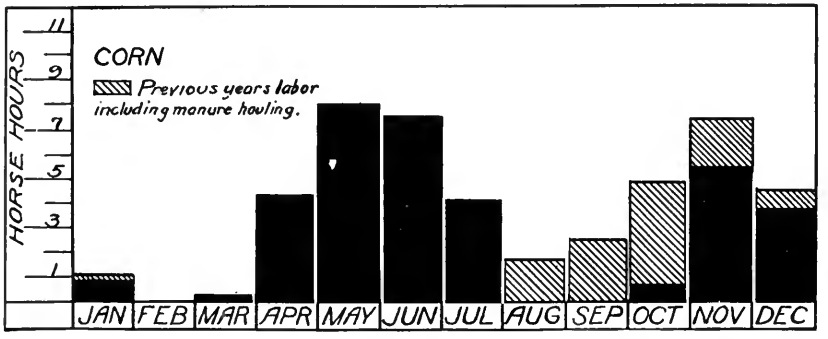


FIG. 4.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF CORN WHEN PLOWING AND MANURE HAULING WERE DONE IN THE FALL. TOTAL HORSE HOURS, 46.1

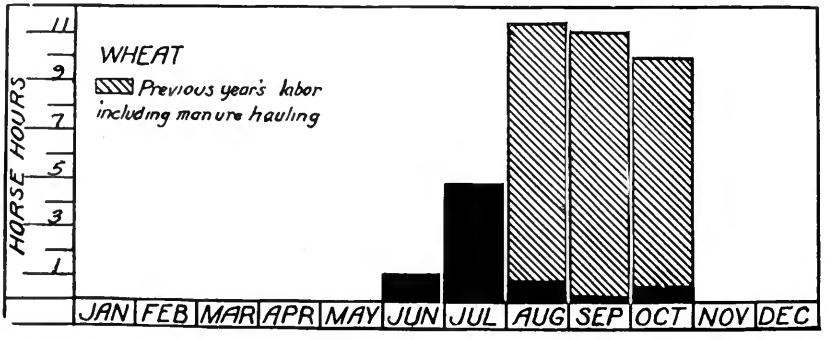


FIG. 5.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF WINTER WHEAT (INCLUDING MANURE HAULING). TOTAL HORSE HOURS, 38.1

which can be worked per horse apparently continues to increase somewhat constantly for farms increasing in size up to approximately 300 acres, i.e., the farms with approximately 240 acres of crops. It is doubtful whether farms above this size would have very much advantage in securing a large number of crop acres per horse. A farm of 300 acres is ordinarily large enough not only to make good use of the most advantageous size of machinery but also to make the best use of the largest number of horses that can be handled by two or three men in performing the different farm operations which represent the peak load of horse labor. In so far as the crop yields show, the larger number of crop acres worked per horse upon the larger farms was not secured at the expense of good farming.

Thru Crop Rotations Securing an Even Distribution of Labor.—One of the fundamental factors in making possible an efficient use of horse labor is a good rotation in which the crops selected will permit the most even possible distribution of horse labor thruout the growing season. In order to construct such rotations which will at the same time meet the requirements of a good rotation from the standpoint of soil maintenance, insect and disease control, and the maximum returns for the crops included, a detailed study should be made of the horse-labor requirement of various crops during the different months of the year.

In Figs. 3 and 4 is shown the distribution of horse labor required by months in producing one acre of corn. These figures represent the average of all farms included in the Hancock-county studies during the five-year period 1913 to 1917. Fig. 3 includes no fall work for hauling manure or fall plowing. Fig. 4, which includes the plowing which was done in the fall and also the hauling of manure, indicates the improvement in the distribution of horse labor which can be effected thru these practices. Fig. 5, which shows the distribution of horse labor in producing an acre of winter wheat, shows the possibilities of this crop in fitting in and making possible an even distribution of horse labor when grown in connection with corn. Figs. 6, 7, and 8 show the distribution by months of the horse labor required in growing oats, clover, and mixed hay, respectively.

Fig. 9 shows the distribution, by months, of the horse labor required in growing a rotation of 80 acres of corn, 40 acres of winter wheat, 40 acres of oats, 40 acres of clover, one-half of which is harvested for hay and one-half used for pasture. Fig. 10 shows the distribution of the horse labor required in growing the somewhat typical corn-belt rotation of 120 acres of corn, 50 acres of oats, 10 acres of mixed hay, and 20 acres of pasture. Fig. 11 shows the distribution of horse labor required in growing the same rotation as represented in Fig. 9, but indicates the possibilities for still further improvement in the distribution of horse labor made possible by doing

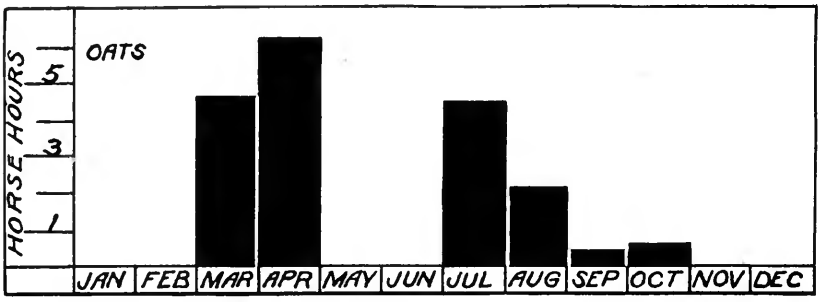


FIG. 6.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF OATS. TOTAL HORSE HOURS, 18.3

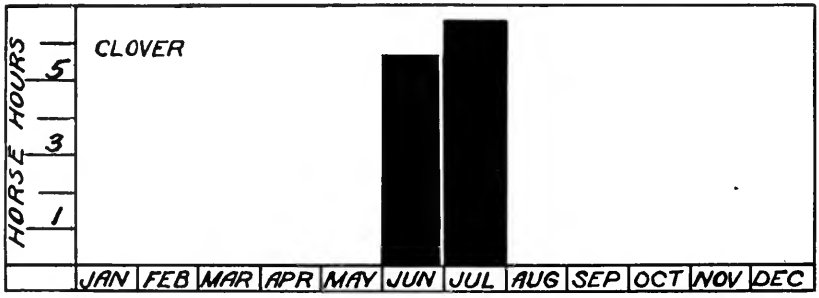


FIG. 7.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF CLOVER, FIRST CROP. TOTAL HORSE HOURS, 12

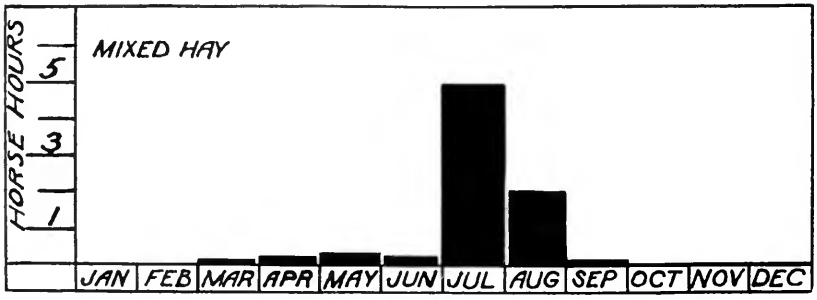


FIG. 8.—DISTRIBUTION OF HORSE LABOR REQUIRED TO PRODUCE ONE ACRE OF MIXED HAY. TOTAL HORSE HOURS, 7.8

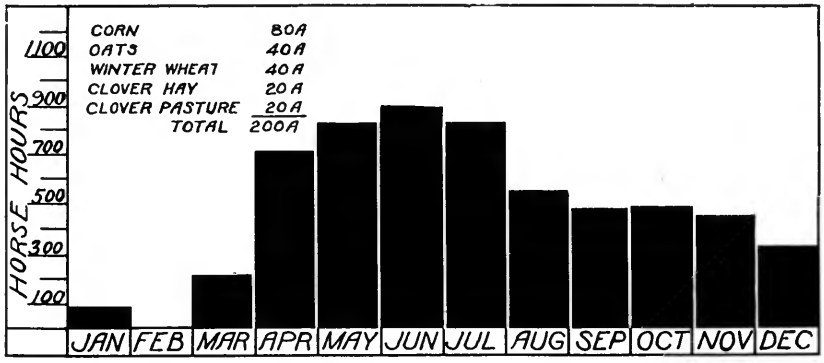


FIG. 9.—EVEN DISTRIBUTION OF HORSE LABOR RESULTING FROM A GOOD CORN-BELT ROTATION. NO PLOWING OR MANURE HAULING IS DONE IN THE FALL

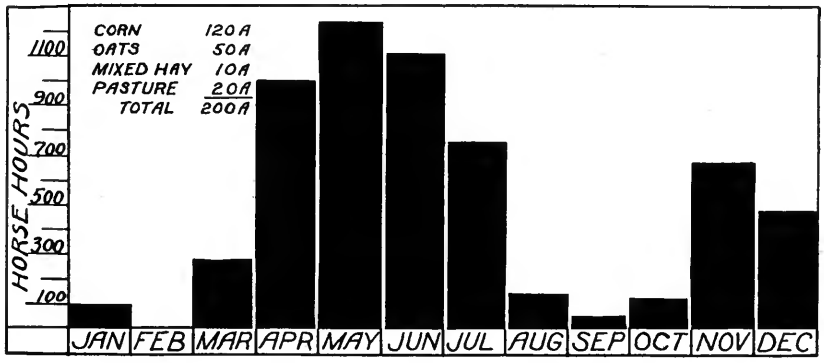


FIG. 10.—UNEVEN DISTRIBUTION OF HORSE LABOR RESULTING FROM A COMMON CORN-BELT ROTATION

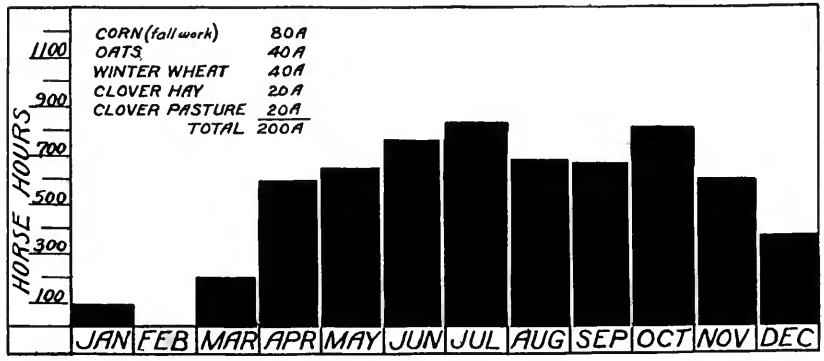


FIG. 11.—UNUSUALLY EVEN DISTRIBUTION OF HORSE LABOR RESULTING FROM THE SAME ROTATION AS THAT REPRESENTED IN FIG. 9, BUT IN WHICH FALL WORK IS DONE IN PREPARATION FOR CORN

as much fall plowing in preparation for corn as was done on some of the farms of Hancock county during the years 1913-1917 inclusive.[1]

Inasmuch as the rotation represented by Fig. 10 is quite typical as to the proportion of various crops grown in a large part of the most important corn-producing areas in Illinois, it is apparent that the distribution of horse labor must be in general quite unsatisfactory from the standpoint of providing the most productive employment for the farm horses during the cropping season. As compared with the rotation represented by Figs. 9 and 11, it is also less satisfactory from the standpoint of maintaining the fertility of the soil, since the proportion of legume crops is too small. As determined by the best available information, rotations in the corn belt should include a legume acreage of from one-fifth to one-fourth of the total crop area. The introduction of winter wheat into the rotation, as represented in Figs. 9 and 11, in addition to contributing very much to the better distribution of horse labor, also reduces somewhat the acreage in oats. This is desirable, since, in the main, oats are relatively less profitable than is winter wheat even in the best corn-growing areas.

From these figures it is evident that in the constructing of rotations which will maintain the nitrogen content of the soil and provide the best combinations of feeds for general live-stock production, there is at the same time an opportunity for selecting combinations which will make possible an increased efficiency in the use of horse labor thruout the cropping season.

Thru the Production of Live Stock.—The production of two or more classes of live stock, particularly where the winter feeding of cattle or sheep is included, helps to provide some productive employment for the farm horses during the period when they would otherwise be idle. This winter labor helps not only in reducing the unit cost of horse labor by providing more hours of productive work, but also in keeping the horses in better working condition thruout the winter and insuring their being more efficient when they go into hard work in the spring. Thus, every step in the direction of a more permanent and a more diversified system of farming is a step in the direction of the more perfect utilization of the farm horse labor.

Thru a Good Physical Organization of the Farmstead.—In attempting to secure the best use of horse labor, the physical organiza-

[1]In Figs. 3 to 11 inclusive, the distribution of horse labor is shown by months. This naturally tends to smooth down somewhat the variations occurring from week to week or from day to day within the month. For the purposes of further analysis many of the horse-labor distributions studied were platted by weeks, by ten-day periods, and by single days. While the platting by shorter periods makes the curve somewhat more irregular, the same general result is obtained with reference to the more even distribution of the horse labor secured by growing a good rotation, as shown in Figs. 9 and 11, as compared with the poor rotation represented by Fig. 10.

tion of the farm and the farmstead must also be taken into consideration. The location of the farmstead and the general arrangement of the field system must be planned with a view to reducing the distance in hauling either to or from the fields. The size and shape of fields also has an important influence in the most effective use of horse labor. The larger the field the more economically can the horse labor be used. In actual practice, a good rule seems to be to have as many fields as there are years in the rotation and to have the fields as nearly the same size as possible. Fields should be rectangular if possible, since triangular and irregular-shaped fields always mean the wasting of some horse labor. In general, fields should be about twice as long as they are wide in order to require as little turning as possible at the ends. This is true even in the corn-belt section, where a somewhat larger proportion of the work must be done crosswise of the field as compared with sections growing less corn. On the other hand, fields that are too long and narrow do not use fencing economically.

A farmstead carefully planned with reference to the location and arrangement of buildings, yards, paddocks, and lanes may also save some time in the use of horse labor. This factor is more important, however, in the saving of man labor than in the saving of horse labor, especially on farms on which live-stock production is of considerable importance.

Thru a Classification and Scheduling of Farm Operations.—Further improvement in the distribution of horse labor thruout the year may be brought about by making a careful study of all operations requiring horse labor and classifying them with reference to whether or not they should be done at a particular time in order to get the best results. From this standpoint farm operations may be classified into *fixed, semi-fixed,* and *movable* operations.

The *fixed operations* are those which must be performed at a definite period, usually within three or four days or a week of a given date, if best results are to be obtained. Thus, the planting, cultivating, and harvesting operations, which require a large proportion of all horse labor used, cannot usually be shifted more than a few days without serious losses in crop returns. Obviously the specific date when conditions are most favorable for performing a particular operation may vary somewhat from year to year, owing to seasonal variations. When the proper time arrives, however, the work must be pushed vigorously and given the right of way over all other work in order that it may be finished during the most favorable period.

The *semi-fixed operations* are those which can usually be shifted from one to three or four weeks without serious disadvantage. Shock threshing, stack threshing, and husking corn are good illustrations of semi-fixed work. Fall plowing can usually be shifted more or less without serious disadvantage. Even spring plowing and some of the

FIG. 12.—IMPROVING TWO CROPS AT ONCE
Draft mares kept mainly for work also produce good foals.

other operations of soil preparation, especially for corn and other crops which should not be planted before a given date, may often be shifted somewhat to fit in between the more fixed operations. This is especially true during early springs, when the conditions for doing field work are favorable. It was largely such shifting that made it possible, in 1918, to finish the spring work in good time in spite of the serious shortage of man labor caused by the withdrawal of farm hands to enter military service or other war work.

The *movable operations* are those which can be shifted over considerable periods, usually from one to three months or even more, without serious disadvantage. Hauling manure and other fertilizers, hauling tile, coal, building material, and miscellaneous farm supplies, are illustrations of movable horse-labor operations.

In Table 8 is shown the proportion of horse labor used by various farm enterprizes or by different departments of the farms studied in Hancock county during the period from 1913 to 1917 inclusive. It

TABLE 8.—PERCENTAGE DISTRIBUTION OF HORSE LABOR BY VARIOUS ENTERPRIZES: HANCOCK COUNTY FARMS, 1913 TO 1917

	Percentage
Live-stock feeding	4.9
Household use	6.1
Equipment (buildings and machinery)	5.7
Miscellaneous	12.3
Field work (crops)	71.0
Total	100.0

will be noted that the horse labor used in field work, i.e., in growing crops and in hauling manure and other fertilizers, made up 71 percent of the total horse labor used on the farms studied. Because of the fact that field work makes up such a large proportion of all farm horse labor, it is apparent that special attention should be given the problem of using horse labor to the best advantage at this point. Since a relatively large proportion of all work in growing crops is fixed, it is doubly important that all field work which is more or less movable should be planned so as not to conflict with the fixed work. This applies especially to fall plowing, early spring plowing, hauling manure, and similar field operations. The importance of planning rotations which will distribute horse labor as evenly as possible thruout the cropping season has already been pointed out.

While nearly all these farms carried on the winter feeding of live stock, the horse labor required by the live-stock enterprize made up only 4.9 percent of the total horse labor used. Practically all this labor was used during the winter months and therefore did not interfere with the work of crop production during the growing season. This labor was utilized mainly in hauling shock fodder, hay, straw, and other

FIG. 13.—THE TWO-ROW CORN PLOW DRAWN BY THREE HORSES
This plow saves man-labor at the period when most man-labor is needed.

feed materials.[1] It provided some productive employment for the horses when they would otherwise have been idle, and served to help keep them in better condition to go into spring work later on.

The use of horse labor by the household, making up 6.1 percent of the total, was for personal service to the farmer and the members of his family. This consisted in going to town for pleasure or personal business, in going to school, to church, and doing miscellaneous driving of a personal character. With the more general introduction of the automobile, the amount of horse labor used in personal driving is gradually decreasing. This decrease will no doubt be still more marked as country roads are improved and automobiles can be used more nearly thruout the year.

The horse labor charged against equipment, i.e., buildings and machinery, made up 5.7 percent of the total. This was used mainly in hauling building materials required in making ordinary repairs and in part for the construction of new buildings and permanent improvements, tho this latter item was relatively small. The horse labor used in going to town for repairs for machinery also made up a somewhat important item.

The use of horse labor for miscellaneous purposes made up 12.3 percent of the total amount. This consisted mainly of such items as dragging roads, cutting weeds, baling hay, cutting silage, and doing

[1]The horse labor used in hauling manure, which would ordinarily be thought of as live-stock work, is charged in these studies against the field to which such manure is applied, since the crops grown on such fields secure the benefit of the application. Thus, the live-stock enterprizes are responsible for a greater percentage of the productive horse labor performed during the slack seasons than is indicated by the percentage shown in Table 8.

farm hauling and driving of a general nature which could not be charged to any special enterprize; i.e., they were items of general farm expense. It also included all "exchange" horse labor performed by the farmer on the farms of his neighbors as well as the horse labor used in marketing grain, seeds, and minor farm products. This latter item is of minor importance, however, since practically all the crops grown on the farms included in these studies are marketed thru beef cattle and hogs.

This classification of horse-labor operations with reference to the time when they must be performed can at best be only an approximate one. What would be at one time and under certain conditions classed a movable operation, might be at another time and under different conditions classed as semi-fixed or even fixed. In general, however, a systematic effort to classify the various farm operations in this way should be helpful in planning the work so that semi-fixed and movable work will conflict as little as possible with the fixed operations. The more skilful the farm operator is in scheduling the work so as to get the movable work done during the slack periods, and the more completely he can make his plans so as to be fully prepared to get maximum efficiency at the peak-load, or rush, periods, the more nearly will he come to getting his fixed operations finished within the time required for best results.

In terms of practical results this means that efficient management helps to cut down the extreme peak load of horse labor which occurs in Illinois at the time of soil preparation and spring planting, since it makes possible a more even distribution of horse labor thruout the cropping season. This is only another way of saying that each horse can do more work, or that a given amount of work can be done equally well by a lesser number of horses.[1]

SIGNIFICANT ILLUSTRATIONS OF VARIATIONS IN THE DISTRIBUTION OF HORSE LABOR

In the discussion of the influence of good farm organization and operation on the even distribution of horse labor thruout the year, the following principal factors have been emphasized: (1) a good crop rotation, (2) the winter feeding of live stock, and (3) the careful planning of the work from day to day and from season to season.

In Figs. 9 and 11 is shown the evenness in monthly distribution of horse labor which would result from using a crop rotation con-

[1]See University of Illinois Extension Circular 20 for a brief discussion of the use of man labor on the farm. This circular also gives a work calendar listing all ordinary farm operations by months, and indicating whether they are fixed, semi-fixed, or movable. The division of labor is also shown by crop, live-stock, and miscellaneous enterprizes.

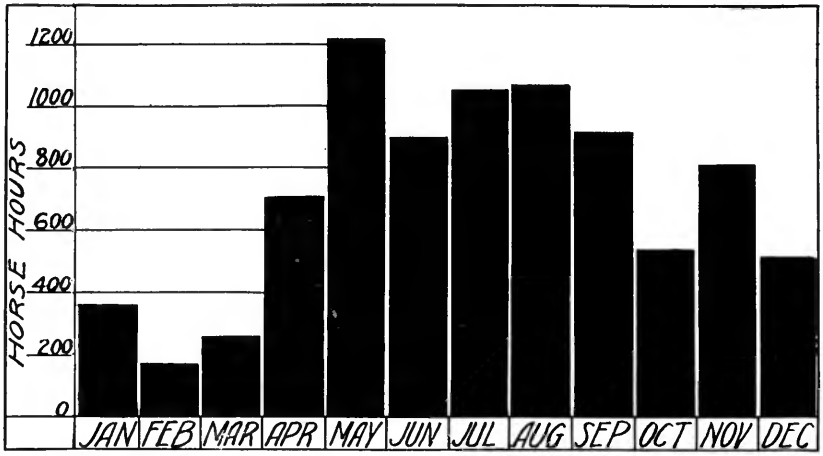


FIG. 14.—GOOD MONTHLY DISTRIBUTION OF HORSE LABOR SECURED ON A FARM OF 160 ACRES BY THE USE OF A GOOD CROP ROTATION INCLUDING A CONSIDERABLE AMOUNT OF FALL PLOWING AND THE WINTER FEEDING OF LIVE STOCK

structed with a view to securing a good distribution of horse labor as well as to meeting the other requirements of a good system of cropping.

The significance of differences which may result from differences in the methods of farm organization and operation is shown by contrasting Figs. 14 and 15. Fig. 14 shows the distribution of all horse labor used on a 160-acre farm during 1913, a somewhat representative year from the standpoint of the use of horse labor. The farm represented by this figure used a fairly good crop rotation, carried on the winter feeding of general live stock to some extent, and managed its work so as to do considerable fall plowing. This farm was fairly typical of the most efficiently operated farms and secured its horse labor at a cost somewhat below the average of all the farms studied. This figure indicates that it is practicable, under actual farming conditions, to secure a good distribution of horse labor thruout the cropping season where a good rotation of crops is used and the work is carefully planned for efficient farm operation. It indicates also that some productive horse labor can be provided during the winter months thru the winter feeding of live stock.

Fig. 15 shows the distribution of all horse labor used on a 320-acre farm on which a somewhat poorer rotation was used. On this farm practically no winter feeding, other than the fattening of hogs, was carried on and very little fall plowing was done. This farm was among the least efficient in the use of horse labor of the farms studied. Because of the poor distribution of horse labor, a relatively large number of horses, in proportion to the number of crop acres, had to be

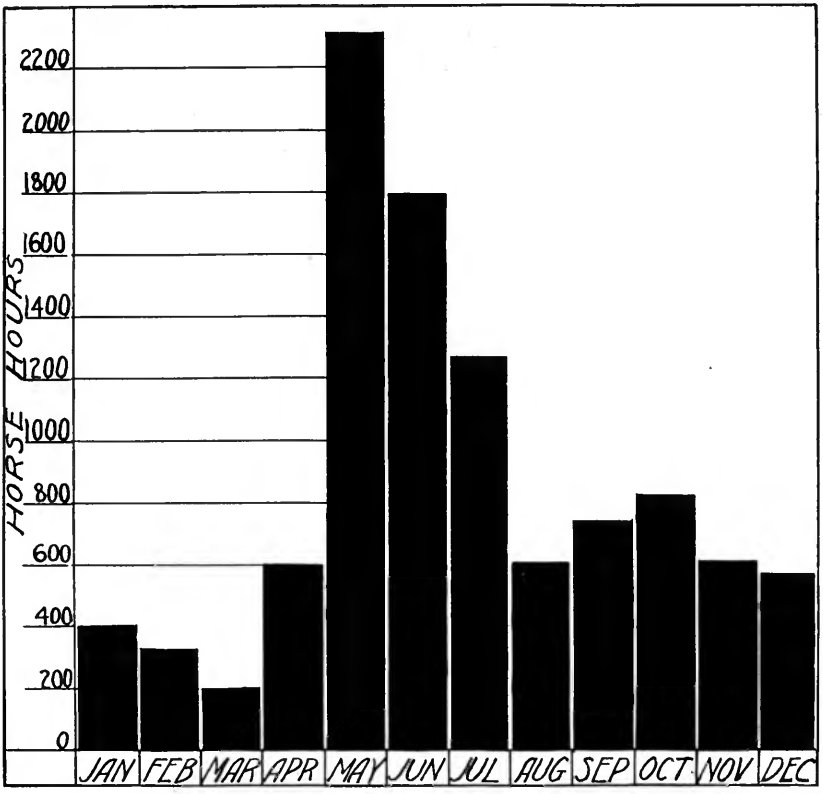


FIG. 15.—POOR MONTHLY DISTRIBUTION OF HORSE LABOR RESULTING ON A 320-ACRE FARM FROM A POOR ROTATION INCLUDING LITTLE FALL PLOWING AND VERY LITTLE WINTER FEEDING OF LIVE STOCK

carried. The costs per unit of work done were therefore relatively high as compared with most of the other farms studied.

These figures—Nos. 14 and 15—represent the horse labor on farms carrying on the same general type of farming, altho the crops produced were grown in somewhat different proportions and the system of live-stock production followed was somewhat different. Both of these farms, however, are representative of a considerable number of farms in the region in which they are located. A study of the differences in efficiency in the use of horse labor found on these two farms makes it apparent that very substantial economies can be effected thru the introduction of the most improved methods of farm organization and operation.

PART IV

ANALYSIS OF FARM HORSE-POWER REQUIREMENTS

CLASSIFICATION OF ALL FARM OPERATIONS

In order to determine as definitely as possible the adaptation of the horse in performing various kinds of farm work as compared with other sources of farm power, an analysis was made of all the farm operations which occurred on the farms studied. On the basis of a careful study of all the cost-accounting records available, as well as the experience of a large number of farmers using both tractors and horses, all the work performed on these farms, whether actually done by horses or not, was divided into three classes: strictly horse, or *non-tractor,* work, *doubtful tractor* work, and *tractor* work. This classification is shown in Table 9.

On only a few of the farms included in the detailed cost-accounting studies were tractors used. The data available, however, show in detail all the operations performed on these farms during the five-year period from 1913 to 1917. They show also the number of horses used in each operation and the amount of time spent, down to quarter hours, on all the work performed during this period. Because of these facts it was felt that the data offered a satisfactory basis for analyzing the work done and classifying it in accordance with the experience of the farmers using both horse and mechanical power.

Under *tractor operations* are included plowing, disking, harrowing, and practically all operations involving soil preparation, as it was assumed that the soil conditions would be favorable and the tractor light enough so that in any of these operations there would be no damage to the soil by packing. In making this classification it was also assumed that in some cases two or more of these operations, would be combined, e. g., disking and harrowing, or harrowing and rolling, as is frequently done in field practice where the tractor is used.

Doubtful tractor operations as classified in this analysis include the drilling of small grain; rolling under certain conditions, as in rolling corn with a corrugated roller; harvesting corn with a corn binder; harvesting small grains, soybeans, and timothy; and pulling a hay loader. All these operations are at times performed with a tractor, but much more frequently they are performed with horses even when a tractor is available. The hauling of purchased feed, fertilizers, such as limestone and phosphate, and building materials, such as gravel, lumber, lime, and cement, are also classified as doubtful tractor. It is assumed that in order to make such hauling practicable with the tractor, a train of two or more wagons would have to be used. Any question, however, as to whether these operations should be classified as tractor or as non-tractor has very little influence on any conclusion which might be arrived at as a result of a study of the total

TABLE 9.—SHOWING OPERATIONS CLASSIFIED AS TRACTOR, NON-TRACTOR, AND DOUBTFUL-TRACTOR; ALSO CLASSIFIED AS FIXED (F), SEMI-FIXED (S), AND MOVABLE (M)

Tractor operations	Doubtful-tractor operations	Non-tractor operations
S. Plowing	M. Hauling gravel (more than one wagon)	F. Cultivating corn
F. Disking	S. Rolling	F. Mowing hay
F. Harrowing	F. Drilling wheat, oats, and rye	F. Planting corn
S. Cutting stalks (with disk)	F. Cutting corn with binder	F. Husking corn
F. Dragging (field)	F. Cutting small grain with binder	S. Hauling manure
M. Pulling hedges	F. Cutting soybeans with binder	F. Plowing in gardens, truck patches, and around ends of fields
F. Rolling and harrowing corn (combined)	F. Cutting timothy with binder	M. Horse labor for household and personal use
F. Cultivating for oats	F. Pulling hay loader	F. Feeding live stock
F. Disking and harrowing (combined)	F. Other hay work; hoisting	M. Miscellaneous hauling about farm
S. Working roads with grader	M. Hauling feed (more than one wagon)	M. Hauling small quantities of products to and from market
F. Harrowing stalks	M. Hauling fertilizers (more than one wagon)	S. Working in garden
F. Pulverizing with Tower Pulverizer		M. Working around farmstead
F. Rolling and harrowing (combined)		F. Cultivating soybeans
		F. Seeding soybeans
		F. Working in seed-corn plot
		F. Threshing; hauling
		F. Raking hay
		F. Tedding hay
		F. Putting hay into barn or stack
		F. Picking up corn after binder
		S. Hulling clover; hauling
		S. Mowing weeds
		S. Opening ditches along fence rows
		M. Baling hay and straw; hauling
		F. Sowing grass seed
		F. Gathering seed corn
		F. Hauling fodder
		F. Cultivating corn with weeder
		S. Raking stubble field
		M. Building and repairing fences
		S. Breaking stalks in winter
		F. Cutting stalks with stalk cutter
		F. Harrowing corn
		F. Rolling corn
		F. Drilling alfalfa
		F. Rolling
		F. Curing alfalfa
		F. Filling silo; hauling
		F. Drilling small grain (one-horse drill in standing corn)

FIG. 16.—A GOOD TANDEM HITCH
This hitch does away with side draft and gives the horses plenty of room to work freely and keep cool.

labor requirements of the farms under consideration, since these operations make up such a relatively small part of the total labor used.

The *non-tractor operations* include by far the largest number of individual farm operations. Naturally many of these are of a minor character and therefore require relatively small amounts of horse labor. In the aggregate, however, they make up a large proportion of the total labor used on the farms studied.

Planting, cultivating, and husking corn, mowing hay, and hauling manure are among the more important operations classified as non-tractor. It is recognized that corn cultivation and many of the other operations classified as non-tractor can be and are sometimes performed by tractors. In making the present classification, however, the operations were listed in accordance with the most economical means of getting the work done, as determined by the experience of the great majority of tractor users. If a tractor were used for work which could as well be done by the number of horses which it was actually necessary to carry, that is, unless it actually displaced horses, the horses would be standing idle while the tractor would be receiving wear and tear, and the total cost of performing the farm operations would not be reduced but rather increased.

Naturally any changes in the design and construction of the tractor which will tend to prolong its life, increase its adaptation, or reduce its cost, will tend to increase its range of economic adaptation. It is likewise obvious that the same general considerations must apply to the horse; if he is to produce the most economic results, he must be of the type which will insure the highest grade of service over the longest period of time for a given amount of money invested or expense incurred.

It is evident that any classification of farm operations such as is here attempted must be to some extent arbitrary. Because the operations studied represented individual farm conditions, and because the actual fields, horses, equipment, and other details were known to those making the distributions, variations from this classification were made when circumstances warranted. To illustrate, while plowing in large fields was always classified as tractor work, regardless of whether it was done by two, three, or five horses, the plowing of gardens, truck patches, or small corners was classed as horse labor, because farmers generally have found it impracticable to do it with the tractor. Also, on the farms where wheat or rye was drilled with one- or two-horse drills, such operations were classified with drilling as doubtful tractor labor. When the same one-horse drill was used to drill wheat or rye in standing corn, the operation was classed as strictly horse, or non-tractor, labor.

ANALYSIS OF ALL WORK DONE ON ALL FARMS, 1913 TO 1917

In Fig. 17 is shown, by months, the distribution of all horse labor (expressed in terms of horse hours) for all the farms in Hancock county which were studied during the five-year period from 1913 to 1917. The labor is represented as *tractor, non-tractor,* and *doubtful tractor* in accordance with the classification shown in Table 9.

The graph shows clearly that a relatively large proportion of the total amount of labor may be classed as non-tractor, or strictly

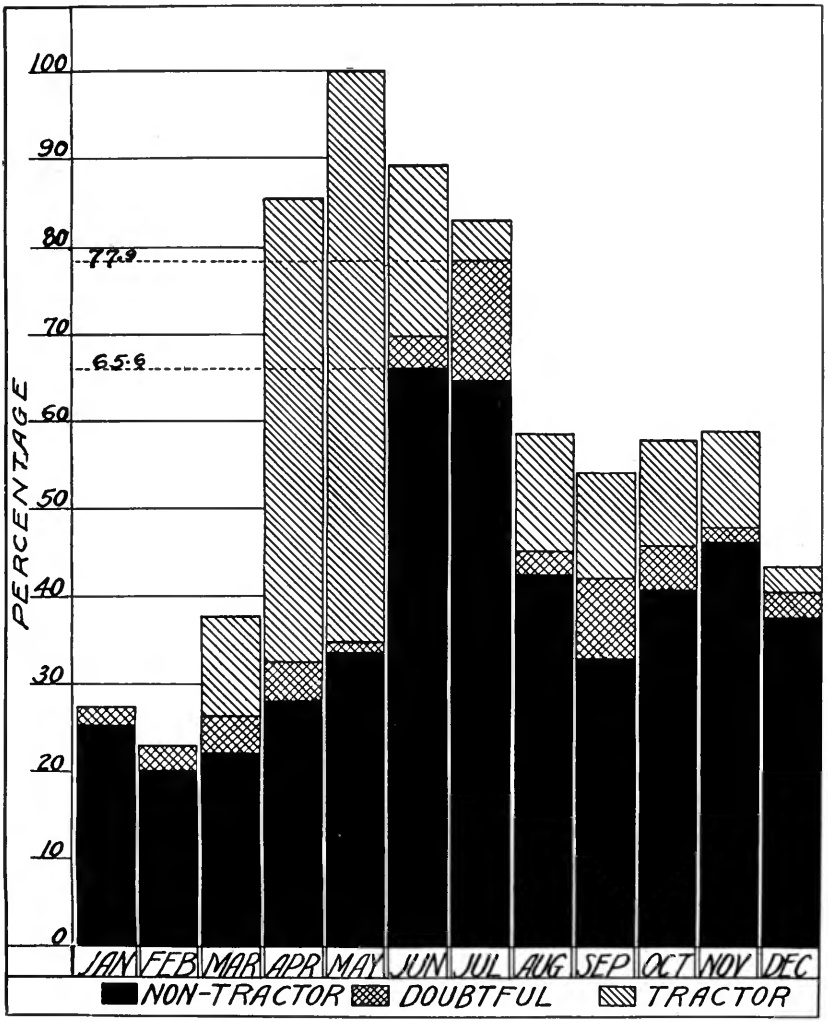


FIG. 17.—MONTHLY DISTRIBUTION OF HORSE LABOR CLASSIFIED AS TRACTOR, NON-TRACTOR, AND DOUBTFUL TRACTOR, AS AN AVERAGE OF ALL FARMS, 1913-1917

horse, labor; and that even tho all the doubtful tractor labor should be classed as tractor labor, the relation between tractor and non-tractor labor would remain substantially the same. Thus, it is evident that unless the tractor can be economically adapted to the performance of a much larger amount of the farm work than is shown in this figure, a very considerable proportion of all work on farms similar to those here represented must continue to be done by horses.

The following figures, showing the proportion of the various crops included in the rotation areas on these farms, will indicate somewhat definitely the cropping systems practiced. Of the total area in crops, corn made up 48 percent; oats, 22 percent; wheat, 5 percent; mixed hay, 16 percent; and clover, 9 percent. These proportions are fairly representative of the entire central section of Illinois and are not essentially different from those found in many of the important corn-belt areas.

By making a somewhat more detailed analysis of the percentages of the various classes of labor, as shown in Fig. 17, the proportion of the horses that could be displaced if a tractor were purchased, may be determined. It will be noted first of all that the peak load of labor comes during the month of May. This was true almost invariably for all the farms studied, except during 1914, when some of the farms performed the peak load during the month of April, owing to an unusually early spring and especially favorable conditions for doing field work. It is evident that the number of horses which must be kept on a farm using only horses will be determined by the peak load of total labor requirements, while on a tractor farm the number of horses that must be kept will be determined by the peak load of non-tractor work, or by the peak load of non-tractor and doubtful tractor work combined. Thus, on farms similar to those represented in Fig. 17, which use only horses, the number of horses that must be kept will be determined by the peak load of labor in May; while on similar farms, on which both tractors and horses are used, the number of horses that must be kept will be determined by the non-tractor peak load in June, or by the combined non-tractor and doubtful tractor peak load, which occurs in July.

As shown in Fig. 17, the peak load of non-tractor, or horse, labor performed in June was equal to 65.6 percent of the total peak load in May. As compared with this, the peak load of combined non-tractor and doubtful tractor work performed in July was equal to 77.9 percent of the total peak load in May.

Since the combined non-tractor and doubtful tractor labor performed in July equaled 77.9 percent of the maximum peak-load requirement, which occurred in May, it is estimated that the tractor could displace a minimum of 22.1 percent of the horses required on these farms. That is, a tractor could displace all the horses required

FIG. 18.—THE THING THE TRACTOR DOES BEST—PLOWING

A tractor that has given several years of satisfactory service on one of the cooperating farms.

to do the work above the level of the maximum combined non-tractor and doubtful tractor peak, which occurred in July. If it is assumed that all the doubtful labor was done by the tractor, the maximum peak load of horse labor would fall in June. This equals 65.6 percent of the total peak load in May. On this basis it is estimated that some farms working under especially favorable conditions might displace 34.4 percent of their horses. In this connection it is interesting to note that the one hundred farms using tractors, as shown in the summary of the tractor survey on page 211, displaced on the average 20.6 percent of their horses; also that of these one hundred farms, the twenty-four that were apparently making the most efficient use of their horses and tractors were able to displace an average of 33.1 percent of their horses. A fuller discussion of the number and percentage of the horses that can be displaced when a tractor is introduced will be found on pages 217 to 219.

The high peak of labor for June and July shown in Fig. 17 is made up largely of labor used in corn cultivation, especially during June, while the peak for April and May is largely for labor used in soil preparation and planting. Hence, when a tractor is introduced, the peak-load period of horse labor shifts from the months of soil preparation and planting to these summer months of corn cultivation. If the maximum number of horses is to be displaced when the tractor is introduced, it becomes increasingly important to reduce the horse labor required in corn cultivation. This can be best effected by the introduction of the two-row cultivator. While the two-row cultivator

may not save a great amount of horse labor during the first cultivation of corn, it makes possible a considerable reduction in horse labor during the second and third cultivation, when haymaking and wheat harvesting compete with corn cultivation for both horse and man labor. The more general introduction of the two-row cultivator, therefore, should assist in securing the maximum displacement of horses when a tractor is used.

From the analysis thus far made, it is evident that a considerable number of operations on farms similar in type to those here included, must still be considered strictly horse, or non-tractor, labor. Since the peak load, or highest requirement, of non-tractor labor must determine within fairly narrow limits the number of horses that must be kept when a tractor is introduced, it also determines somewhat definitely the amount of work which the tractor will perform to the greatest advantage. Thus, on the farms represented in Fig. 17 the tractor will have its greatest advantage in performing the work which comes above the level of the non-tractor peak, for here it can actually displace horses and therefore make a definite saving. Any tractor work, however, represented by the area below the level of the highest non-tractor peak represents work which might have been done by the horses necessarily kept to perform the non-tractor labor. In other words, the tractor is being used to perform work that could be done by the number of horses which must necessarily be kept to do the non-tractor work, and the horses are idle while the tractor is doing their work.

It will be noted from Fig. 17 that the non-tractor, or strictly horse, labor is distributed much more evenly thruout the year than is the combined tractor, non-tractor, and doubtful tractor labor. It is evident, therefore, that the horses which must be kept to do the non-tractor work can be used to much better advantage when a tractor is introduced to take care of the extreme peak load of labor, which occurs during April, May, June, and July. Each horse can then be worked a greater number of hours during the year, which means a reduction in the cost per hour or other units of work performed by horses. Because of these facts it becomes increasingly difficult for the tractor to compete economically with the horse in the performance of the work which is classified as strictly horse work.

Since the tractor has a special advantage in performing that portion of the work in which it can actually displace horses, it follows that it should be purchased *mainly* to take care of this strictly tractor peak and that on those farms which are large enough to fully utilize a tractor in the performance of this portion of their work, it will have its greatest advantage.

PART V

THE TRACTOR SURVEY

LOCATION AND DISTRIBUTION OF TRACTORS STUDIED

In order to learn as accurately as possible what results the average tractor owner is actually obtaining in the operation of his tractor under field conditions, a survey of one hundred farms using tractors was made during the winter of 1918-1919. These farms are all located in the central portion of the state, as follows:

Woodford county	27 tractors
McLean county	21 tractors
Tazewell county	21 tractors
Champaign county	26 tractors
Moultrie county	4 tractors
Bureau county	1 tractor

In Woodford, McLean, Tazewell, and Champaign counties a farm-to-farm survey was made in cooperation with the farm advisers, who assisted, in so far as possible, in the securing of records. Information was obtained from practically every farmer in the areas selected who had used a tractor one or more seasons. A few individuals were missed because of absence, but the principle of getting a fair average of tractor experience was strictly adhered to. The five records secured in Moultrie and Bureau counties were obtained somewhat incidentally in connection with farm-management extension work in those counties. A number of records were also obtained in southern Illinois. These are not included, however, with those from the corn-belt section. In no case did tractor owners refuse to give the data asked for, and it is thru their hearty cooperation that the results of their experience are here made available.

GENERAL SUMMARY OF TRACTOR DATA

The averages of the one hundred records secured from tractor farms in the corn-belt section are summarized in Table 10.

Thirty of the tractor owners had had previous tractor experience, an average of six and one-half years each. Eighty-eight had had automobile experience, and ninety-two had had experience with gas engines. Many of the tractor operators expressed the opinion that it would pay prospective tractor operators to attend a tractor school before attempting to run a tractor. Practically all the tractors were run by the owner or some member of the family.

Thirty-two farmers used the tractor for cutting grain. One farmer pulled two binders with his tractor, while the others pulled only one, with a man to operate the tractor and another the binder. The advantage claimed for using the tractor to harvest grain was that in hot weather very much more grain could be cut per day than would be

TABLE 10.—SUMMARY OF TRACTOR SURVEY

(Average of 100 farms)

Years of tractor use	2.21
Size of farms, acres	294.
Crop acres	246.7
Corn acreage	120.
Oats acreage	76.7
Wheat acreage	26.8
Hay acreage	23.2
Number of work horses in 1918	9.14
Number of work horses before getting tractor	11.52
Number of horses displaced	2.38
Percentage of horses displaced	20.67
Crop acres per horse before getting tractor	21.4
Crop acres per horse in 1918	27.
Cost of tractor	$1134.49
Cost of plows	$151.85
Hours required daily for tractor chores	.95
Estimated life of tractor, years	5.8
Number of three-plow tractors	85.
Number of two-plow tractors	10.
Number of more-than-three-plow tractors	5.

Work Done with Tractor in 1918

	Number of acres	Approximate days per farm[1]
Plowing	117.37	16.79
Disking	94.44	4.72
Harrowing or rolling	38.07	.76
Cutting grain or loading hay	29.62	1.18
Road work	....	1.23
Total traction work	....	24.68
Belt work	....	5.17
Total tractor work	....	29.85

[1]Calculated from the amount of work done, using seven acres of plowing, twenty acres of disking, fifty acres of harrowing, and twenty-five acres of grain cutting as a full day's work for a three-plow tractor.

possible with a four-horse team. On two of the farms the tractors were also used in pulling a hay loader.

In cases where the size of the farm was increased after a tractor was purchased, the number of horses displaced was calculated on the basis of the number that would have been needed with the increased acreage if no tractor had been added. For example, if ten horses had worked 200 crop acres before a tractor was purchased and 240 crop acres afterwards, the tractor was credited with displacing two horses, based on the calculation that without the tractor twelve horses would have been required. When the crop acres were reduced after a tractor was obtained, corresponding adjustments were made. It is interesting to note, however, that only three farmers increased their crop acreage after purchasing a tractor, one by 50 acres and the other two by 80 acres each. One farmer worked 30 crop acres less after adding a tractor.

On the basis of the best figures available,[1] it is estimated that the cost of operating a farm tractor varies from $300 to $600 a year. In order to justify this expenditure it seems logical to assume that the farmer must effect a corresponding saving at some other point in his business, or bring about a corresponding increase in production.

BASIS FOR STUDYING THE USE OF THE TRACTOR

In order to determine as accurately as possible what influence the tractors studied had upon the farm returns, the data obtained from the one hundred farms will be considered on the basis of the following five important factors: (1) custom work done; (2) belt work done on own farm; (3) increases in crop yields; (4) saving in man labor; and (5) saving in horse labor.

Custom Work Done.—The possibility for profitably doing custom work seems to have been rather limited so far as field work is concerned. A few of the tractors studied were used for road grading. If such work can be done during slack periods it may prove to be a profitable undertaking. Doing belt work, such as threshing, filling silos, and shelling corn for other farmers may perhaps also be done at a profit, altho the margin of profit does not seem to be great enough to induce many tractor operators to leave their own farms. Only fourteen of the one hundred tractor owners did custom belt work. Four of these fourteen did road grading in addition. The amount of belt work done by these fourteen tractors averaged 19.8 days per tractor per year. Table 11 shows the kind and amount of belt work done by the fourteen tractor owners who did custom work.

TABLE 11.—CUSTOM BELT WORK DONE BY TRACTOR OWNERS

Kind of work	Number of tractor owners	Days work per tractor
		Average
Threshing	13	15.6
Cutting silage	5	3.6
Shelling corn	1	15.0
Hulling clover	2	17.5
Baling hay or straw	1	7.0

Belt Work Done on Own Farm.—Sixty-six of the one hundred farmers used their tractors for belt work, fifty-two of them on their own farms only, and fourteen, as previously stated, for custom work as well. The average amount of this work on the fifty-two farms not doing custom work was five days per year. Table 12 shows the kind and amount of each class of belt work done.

[1]Based on records kept by the Farm Mechanics Division, and cost-accounting data secured by the Department of Farm Organization and Management, University of Illinois.

TABLE 12.—BELT WORK DONE BY TRACTOR OWNERS ON THEIR OWN FARMS

Kind of belt work	Number of tractor owners	Days work per farm
		Average
Threshing	7	2.5
Cutting silage	21	2.1
Shelling corn	5	2.1
Baling hay and straw	12	3.8
Grinding feed	25	3.4
Running grain dump	7	3.3
Cutting wood	12	2.1

Three of the seven tractor owners who reported using their tractors for threshing are also included in the twenty-one who used their tractors for cutting silage, while four did threshing only. Thus, twenty-five in all did either threshing or silage cutting, or both; that is, 25 percent of the total number of tractor owners used their tractors for heavy belt work. The lighter belt-work operations, such as grinding feed, shelling corn, or cutting wood, were more or less incidental and would not in themselves justify the purchase of a high-priced power outfit, nor would they contribute much towards making it pay for itself.

There are other sources of power which may compete with the gas tractor in doing belt work; namely, electric motors, portable gas engines, steam engines, and horses. Some corn-belt farmers are making excellent use of good horse-power outfits for corn crushing and similar work, which usually comes during the slack season. For this work it

FIG. 19.—A SMALL-SIZED THRESHER HELPING TO SOLVE THE LABOR PROBLEM

This tractor has furnished satisfactory belt power for threshing on several of the cooperating farms.

is of advantage to use horses, not only because they furnish belt power at low cost, but also because such work helps to keep the farm horses in better condition. Horses also have some obvious advantages over gas engines in cold weather. Which of these sources of power will be the most economical will depend on local conditions and upon the possibility of hiring power for the heavy belt work when it is needed.

Increase in Crop Yields.—Claims are often made that the tractor enables the farmer to plow deeper, to do the work in a shorter time, and to better prepare the seed bed. All these advantages should ultimately be reflected in the crop yields. None of the one hundred farmers interviewed, however, gave increased crop yields as an advantage for the tractor. Some mentioned deeper plowing and timeliness as advantages, but they were not prepared to say that these advantages had as yet been reflected in greater crop yields. It is quite probable that the use of the tractor has resulted in increased crop yields where the horse power was inadequate to properly perform the work before the tractor was added.

Saving in Man Labor.—At no time has the tractor had a better opportunity to effect a saving in man labor than during the season of 1918. Unless the situation is analyzed carefully, however, there may be an over-estimation of the importance of the saving in man labor that resulted from the use of the tractor during that period. During that year more acres were worked per man on farms in general, whether tractors were operated or horses alone were depended on for power. This was accomplished in part by working harder, and in part by confining work almost entirely to productive enterprizes. Much work, such as repairing fences and buildings, was postponed until more help was available, and in general, labor was concentrated on crop production.

The number of days of plowing done with the tractor on these one hundred farms, as shown in Table 10, averaged 16.8 per farm. The number of days of disking averaged 4.7. These were practically the only operations in which any saving in man labor resulted. Counting seven acres as a day's plowing with a three-plow tractor, the farmer may accomplish 50 to 75 percent more work with a tractor than he could with the usual four- or five-horse team. Applying the same advantage to disking, a saving of sixteen days in man labor may be assumed to result from the introduction of the tractor—that is, 75 percent of 21.5, the average number of days of plowing and disking done with the tractor. The peak-load period of horse labor, which in the corn belt comes during April and May, lends itself well to the use of the tractor, since it is made up largely of plowing, disking, harrowing, and similar tractor operations. But the peak-load of man labor comes in June and July during corn cultivation, haying, and harvest-

ing. If extra men could be hired during these months to take care of this peak-load, the saving in man labor during April and May made possible by the use of the tractor would naturally become of much greater importance, since more land could then be farmed by a given number of permanent, or yearly, men.

In estimating the saving in man labor due to the addition of the tractor, there must also be taken into consideration the tendency toward using more horses per man for plowing and disking, which makes it possible for one man with horses to equal more nearly the performance of a man with a three-plow tractor.

It is evident, therefore, when all factors are considered, that on most farms the saving of man labor is not a large item in favor of the tractor.

Saving in Horse Labor.—The principal saving in horse costs effected by the tractor must come thru actually displacing horses. It is true that the feed cost is less when horses are idle than when they are at hard work, but most farmers agree that it is poor practice to do work with a tractor which could be done by horses that are standing idle. The profitableness of the tractor in the corn belt depends not so much on the total number of days it is used per year as on its ability to reduce the number of horses that need to be kept thruout the entire year in order to take care of the great peak load of horse labor that without the tractor comes at the time of spring planting.

That a tractor makes possible the obtaining of a much larger number of days of work per horse per year from the horses which must still be kept when a tractor is added has already been pointed out. This additional use of the horses means of course that they will need to be kept indoors and fed a somewhat heavier ration during a greater portion of the year, thus increasing slightly the carrying cost per horse per year; but to offset this disadvantage is the advantage that the use of the tractor presents in relieving the horses of much of the heaviest work in the spring, when many horses become badly run down and consequently require extra feed to bring them back to normal condition later on in the season, and in having them better fitted for the lighter work, such as harrowing, cultivating corn, and similar operations.

It is only fair to point out here that the tractor possesses, in addition to its advantage in saving horse labor, a still further advantage in enabling the farmer to speed up the work of ground preparation. If, for example, a sixteen-horse farm (i. e., a farm growing about 320 acres of crops) adds a tractor to its equipment which can do the work of eight horses in plowing or disking, it can dispose of four horses and still have the equivalent of twenty horses available for the work to be done.

POSSIBILITIES IN USING TRACTORS

In attempting to determine as accurately as possible when a farmer may logically begin to consider the purchase of a tractor, the question arises: How many horses can be carried for what it costs to operate and maintain a tractor? for as has already been stated, the number of horses which can be displaced is the chief consideration. As a rule, the corn-belt farmer will be justified in considering the addition of a tractor to his power equipment when the cost of carrying the horses which can be displaced is equal to the cost of operating and maintaining such a tractor.

The most reliable information available regarding the cost of operating and maintaining tractors has been collected by the Farm Mechanics Division of the University of Illinois. The average cost per tractor during 1918 for the sixty-two tractors regarding which data were gathered was found to be $428.87. This cost included interest and 20 percent depreciation (the original cost of these tractors averaged $1,107.25). The average cost of maintaining a farm work horse in 1918, as shown in Table 2, was $156.58. Figured on this basis, the average annual cost of operating and maintaining a tractor was equal to the cost of keeping 2.7 horses.

The question is often asked, Do not farmers displace more horses after having had a greater amount of experience with their tractors than they do at first? In Table 13 the tractor data obtained from the one hundred farms included in the survey are summarized according to the number of years which the tractors on these farms

TABLE 13.—TRACTOR DATA SUMMARIZED BY YEARS OF TRACTOR USE

Years of tractor use	Number of farms	Average size of farms, *acres*	Average crop acres	Percentage horses displaced	Crop acres per horse		Days of tractor work	
					1918	Before getting tractor	Traction	Belt
1	29	265	215	20.8	26.8	21.2	28.6	3.5
2	34	291	243	20.5	28.0	22.2	23.5	4.4
3	25	290	243	23.2	27.0	20.7	23.1	5.5
More than 3	12	389	338	16.7	25.2	21.1	24.2	11.8

had been used. It will be noted that the most efficient use of horse and tractor power as indicated by the crop acres per horse was made on the farms that had used the tractor for two years. However, neither the crop acres farmed per horse in 1918, nor the percentage of horses displaced, seem to bear any consistent relation to the number of years of tractor use.

In Table 14 the data are summarized according to the number of crop acres farmed.

The first three groups of farms had an unusually small crop acreage per horse before the tractors were purchased; and this fact partly

TABLE 14.—TRACTOR DATA SUMMARIZED ON THE BASIS OF CROP ACRES FARMED

Group No.	Number of farms	Average crop acres	Percentage horses displaced	Crop acres per horse		Days of tractor work	
				1918	Before getting tractor	Traction	Belt
1	22	130	24.9	24.9	18.7	17.6	3.7
2	22	177	25.4	24.9	18.5	22.8	3.4
3	22	215	28.0	27.5	19.8	27.8	4.3
4	18	294	15.5	27.6	23.4	26.8	10.2
5	17	465	13.3	28.3	24.5	30.2	5.4

accounts for the large proportion (24.9 to 28 percent) of their horses which they were able to displace when they added a tractor. Before purchasing tractors, Groups 4 and 5 worked from four to six more crop acres per horse than did Groups 1, 2, and 3. Afterwards they worked from one-tenth to three and four-tenths more crop acres per horse than did Groups 1, 2, and 3. Consequently, altho the percentage of horses displaced in Groups 4 and 5 was much smaller than in Groups 1, 2, and 3, Groups 4 and 5 really made the best use of both their horses and their tractors. With one exception, the days of traction work increased somewhat uniformly with the size of the farms. It may be concluded, therefore, that the efficient use of both horses and tractors tends to increase as the size of the farm increases up to the point represented by these figures, i. e., 465 acres.

In Table 15 the data are summarized on the basis of the number of horses displaced when the tractor was introduced. The variations in the percentage of horses displaced must be studied in connection with the crop acres worked per horse before the tractor was used, as well as the crop acres worked during 1918.

The first group, which includes but one farm, added two horses in 1918, as well as the tractor. The crop acres worked per horse before the tractor was obtained, however, had been unusually high (27.5).

TABLE 15.—TRACTOR DATA SUMMARIZED ON THE BASIS OF THE NUMBER OF HORSES DISPLACED

Group No.	Number of farms	Number of horses displaced	Percentage horses displaced	Crop acres per horse		Days of tractor work		Average size of farms, *acres*	Average crop acres
				1918	Before getting tractor	Traction	Belt		
1	1	−2	–	22.9	27.5	29.0	2.0	320	275
2	28	0	0	23.2	23.2	16.1	6.4	318	266
3	7	½ to 1	9.5	23.1	20.9	19.3	6.0	240	203
4	18	1½ to 2	20.3	25.5	20.3	20.9	4.7	245	191
5	9	3	35.0	31.0	20.1	24.7	4.7	202	173
6	24	4	33.1	32.0	21.4	33.1	5.6	301	259
7	6	5	40.5	31.1	18.5	30.5	.3	278	228
8	6	6	30.8	28.0	19.4	42.0	4.2	452	378
9[1]	1	8	33.3	43.1	28.3	47.0	0	740	690

[1]This farm had two tractors.

Consequently, even after two work horses and a tractor were added, the number of crop acres per horse was still almost as high as the average number for the twenty-eight farms in the next group, which displaced no horses.

The twenty-four farms in Group 6, which displaced an average of four horses, or 33.1 percent, apparently made the best use of their horses and tractors combined of any of the groups. After adding the tractor, these farms worked an average of 32 crop acres per horse, the highest acreage for any group excepting the single farm in Group 9.

The fifteen farms in Groups 5 and 7 made almost as good use of their horse and tractor combinations as did the farms in Group 6. They worked an average of 31 and 31.1 crop acres per horse, respectively,

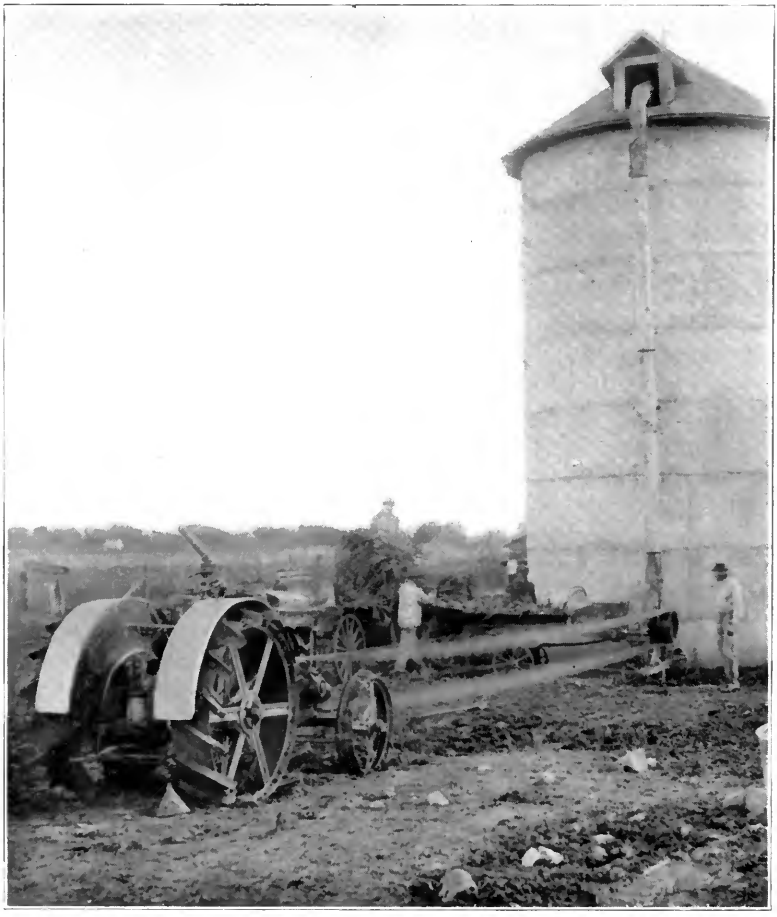


FIG. 20.—A WIDELY USED THREE-PLOW MODEL
Silage cutting is one of the most important belt-power jobs.

after obtaining a tractor. The high percentage of horses displaced by the tractor in these two groups, especially in Group 7, was due to the fact that these farms had been carrying more horses than were really necessary before they introduced the tractor. The farms in Group 7 kept an average of 12.3 horses and worked only 18.5 crop acres per horse before getting their tractors. If they had worked 21.4 crop acres per horse (the average number for the entire hundred farms before adding tractors), they would have needed an average of only 10.6 horses per farm instead of the 12.3 horses actually carried. Under these conditions, with a displacement of 3.3 horses instead of 5 per farm, the reduction in the number of horses would have equaled 31 percent instead of 40.5 percent.

The single farm in Group 9 actually worked the largest number of crop acres per horse both before and after introducing the tractor; namely, 28.3 crop acres per horse before adding the tractor and 43.1 crop acres afterward. This large number of crop acres worked per horse both before and after the tractor was introduced was made possible by several factors: First, the farm was much larger than the average of the other farms studied, this factor alone making possible the use not only of one but of two tractors to good advantage. Then the cropping system was well adapted for a large acreage, and the operation of the farm was especially efficient thruout. It is significant, however, that the percentage of horses displaced by the two tractors used on this farm was 33.3, or one-third of the total number, which seems to represent the maximum displacement with the best management and under present conditions of tractor development.

Since the farms in Group 6 made up 24 percent of the total number of farms in the survey and on the whole apparently made the most efficient use of their horse and tractor power, it may be worth while to study this group somewhat more in detail. The average amount of work done with the tractor on these farms, compared with the average of all farms, is shown in Table 16.

The chief advantage in the use of the tractors in Group 6 resulted from their larger use for plowing and disking. The use of a tractor in

TABLE 16.—AVERAGE AMOUNT OF WORK DONE BY THE 24 TRACTORS USED TO BEST ADVANTAGE COMPARED WITH AVERAGE TRACTOR WORK ON ALL FARMS

	Average of 24 farms in Group 6	Average of all farms
Acres plowed	143	117
Acres disked	154	94
Acres harrowed	59	38
Acres of grain cut	48	29
Days of road work	1	1.2
Total days of traction work	33	24.7
Average number of crop acres	259	246

pulling an eight-foot grain binder is not economical except during a hot season, when horses cannot do a good day's work.

From the results which these one hundred representative tractor owners in the corn belt secured with their tractors, it is apparent that some were working so large a crop acreage per horse before securing a tractor that they were unable to displace many of their horses upon the advent of the tractor; while about the same number apparently had more horses than they needed before getting a tractor and consequently were able to dispose of a relatively high percentage of their horses.

Then, too, in a group of one hundred farmers some will be inclined to "play safe" in disposing of horses, while others will overdo the matter and displace too many. It is believed that the average of the one hundred farms included in this survey may be assumed to represent fairly accurately the average possibilities for displacing horses on corn-belt farms under present conditions. Naturally any changes in the type of farming, the design of tractors and farm machinery, and the skill of the tractor operator may result in a wider or narrower economic adaptation of the farm tractor.

It must be remembered that this study of the tractor has been confined to the corn-belt section of Illinois. In the winter-wheat section of the state the horse-labor distribution is quite different, the proportion of possible tractor work to non-tractor work being considerably higher. When winter wheat, instead of corn, is the main crop, the peak load of total labor comes in August and September, rather than in April and May, while the peak load of non-tractor work comes in July and is considerably lower than the peak load of total labor. On fifty farms located in Madison and Clinton counties in which the crop acreage was made up of winter wheat, 57 percent; of corn, 22 percent; oats, 11 percent; and hay, 10 percent, 30.4 percent of the horses were displaced when a tractor was added. The fact that the farms in the wheat-growing counties are smaller than those in the corn belt has been the principal reason, no doubt, for fewer tractors being used in the wheat-growing section.

SUMMARY

Horse labor makes up from 30 to 40 percent of all farm operating expense in the corn belt and is the one item, above all others, which can be profitably reduced by good methods of farm organization and operation.

The Cost of Horse Labor.—The total cost of horse labor on the farms under investigation in Hancock county, during the years 1913 to 1918, was found to be made up in the following proportions: feed, 72 percent; labor, 11.28 percent; interest, 8.03 percent; shelter, 3.10 percent; harness, 3.44 percent; and miscellaneous expenses, 2.2 percent. Thus, the cost of feed is the most important item to be considered in studying the cost of carrying farm work horses.

The average annual cost of keeping horses during the years 1913 to 1916 inclusive, on the farms studied, ranged from $87.09 to $96.02 per horse. In 1917 it increased to $130.94 and in 1918 to $156.58.

The variations in efficiency of horse labor on different farms in the same locality were extreme, even tho the conditions of production were essentially the same. Such variations may be responsible for differences of from $1.19 to $4.58 in the cost of producing one acre of ordinary corn-belt crops.

Reducing the Cost of Horse Labor.—Reducing the costs of horse labor is effected by reducing the total carrying cost and by securing the largest possible amount of productive work per horse.

Reducing the total cost of carrying horses is effected mainly by: (1) economical feeding, care, and management; (2) raising good colts; and (3) reducing depreciation charges so far as possible.

Securing the largest amount of productive work per horse is effected mainly thru: (1) a farm sufficiently large; (2) a good rotation of crops which will provide an even distribution of horse labor thruout the year; (3) the production of two or more classes of live stock; (4) the most convenient layout of the field system; and (5) a careful classifying and scheduling of all farm work so as to distribute the fixed, the semi-fixed, and the movable horse labor as evenly as possible thruout the year.

Extreme variations in the distribution of horse labor thruout the year were found on representative farms. These variations were due largely to differences in the crop rotations practiced. Since crops utilize 71 percent of the total horse labor, a study of rotations is of great importance.

Displacement of Horses by the Tractor.—Approximately 25 percent of the total labor performed on farms may be classified as tractor, and approximately 75 percent as either non-tractor or doubtful tractor labor.

When only horses are used on a farm, the number required is determined by the peak load of labor, which in the corn belt occurs normally during the month of May in connection with soil preparation, corn planting, and cultivation; but when a tractor is added to the equipment, the number of horses required is determined by the peak load of non-tractor labor, which occurs in June and July in connection with corn plowing, haymaking, and harvesting.

From an analysis of the cost-accounting data from farms using horses only, it is estimated that such farms could, in general, displace 22.1 percent of their horses if a tractor were added to the equipment, and under the most favorable conditions could displace 34.4 percent of their horses. For the one hundred farms studied in the tractor survey, the average horse displacement actually effected when the tractor was added was 20.6 percent. The horse displacement effected by the twenty-four farms which made the best use of their horses and tractors combined was 33.1 percent.

Advantages of the Tractor.—The principal advantage in the use of the farm tractor comes thru the actual displacement of horses. The tractor may also have some advantage in relieving the horses which cannot be displaced of some of the heaviest work during the peak-load periods, and also in speeding up the work.

Of the one hundred farms included in the tractor survey, none reported increases in crop yield as an advantage secured by using the tractor. It is evident that such increases, if there were any, would be difficult for the farmer to determine accurately, especially for so short a period as that covered by these studies.

Relatively little saving in man labor was effected by the use of the tractor.

CONCLUSIONS

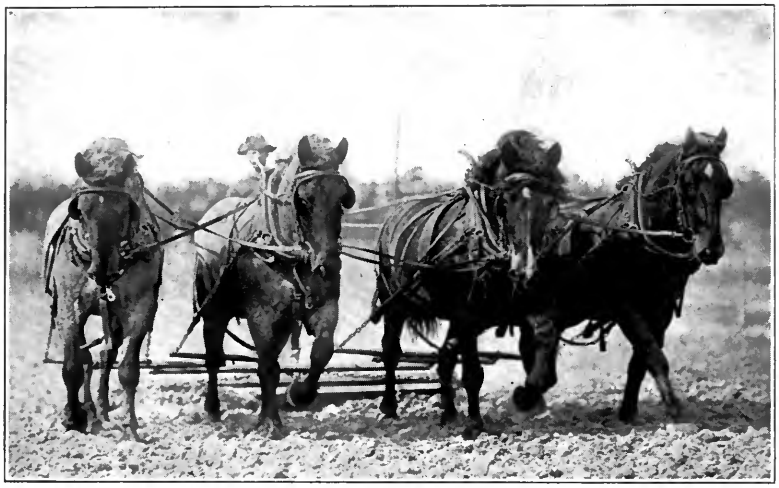
Judging from the experience of farmers as based on the costs of using both horses and tractors, as well as from all other data available, we may conclude that on the average corn-belt farms growing less than 240 acres of crop, the horse costs cannot be reduced enough to offset the cost of operating a tractor. This does not mean, however, that *every* corn-belt farm with more than 240 acres should use a tractor, nor that smaller farms will always find a tractor unprofitable, for other factors than area must necessarily be taken into consideration, but 240 acres is the best approximate expression of size. Most important among these other factors are the following:

1. The annual cost of keeping horses on a given farm may be above or below the average. In 1918 these costs varied from $125 to $192 per horse on the farms studied. Obviously with the higher cost of keeping horses, a smaller number would have to be displaced to justify the use of a tractor, and conversely, the lower cost would necessitate the displacement of a larger number.

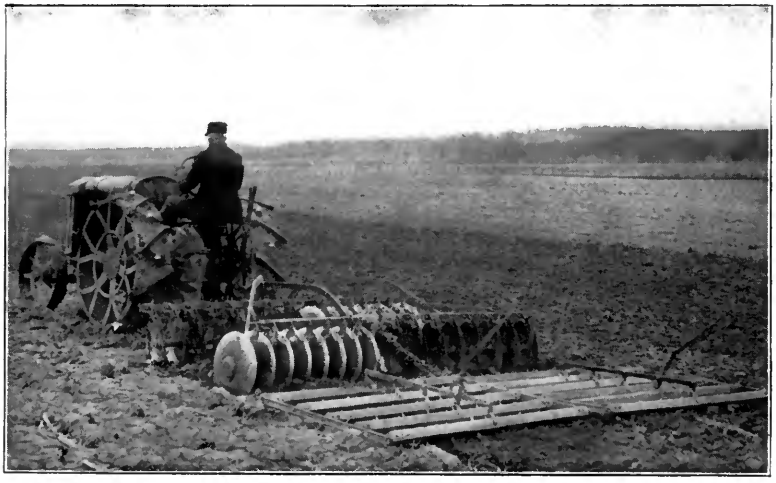
2. There may be a special need for belt power on a farm or in the neighborhood, which would help to provide profitable work for the tractor.

3. The tractor operator may be above or below the average in efficiency. At present this factor, which is a very important one, is extremely variable. Steady operation, low repair costs, and a low rate of depreciation go with the efficient operator; while the contrary is true with the inefficient operator.

Naturally when all three of the above factors are in favor of the tractor, the farm on which it can be profitably used may have considerably less than 240 acres of crops. When all these factors are against the tractor, it will not prove a profitable investment even on the largest farms in the corn-belt.



A Good Four-Cylinder Motor
Here there is weight, action, and plenty of reserve power.



A Popular Type of Two-Plow Tractor
Doing a good job of soil preparation.